ASSESSMENT OF

CLIMATE AND SOCIO-ECONOMIC IMPACTS AND RESPONSES

FOR

RICE PRODUCTION AND DISTRIBUTION IN INDONESIA

MASATO KAWANISHI

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Abstract

This thesis arises from a concern about food security in Indonesia under the impacts of climate variability and change. Food security is a highly important and complex task for the government as Indonesia is the world's fourth most populous country with more than 17,000 islands. The present study targets rice, the staple food of most of her population, and focuses on its availability, in particular production and distribution.

The overall objective of this study is to assess climate and socio-economic impacts on food security, and evaluate market and policy responses in Indonesia. In order to achieve this objective, it starts with an overview of the following issues: (1) the historical and current socio-economic problems concerning rice production and distribution, (2) the observed and projected climate variability and change, (3) the way that climate impacts exacerbate the existing socio-economic problems, and (4) the recent policy responses of the Indonesian government.

With the above objective and background, this study has three research components. Firstly, it examines the combination of climate and socio-economic factors that have contributed to land use conversion from rice production to oil palm plantation. It also identifies types of farmers' responses, and the variables that differentiate them. North Sumatra was selected as the target area of this study because it is a significant producer of both rice and palm oil, where competition for land use is fierce. As publicly available data is limited, interviews with government officials and farmers, as well as focused group meetings with relevant agencies, were conducted to identify the causes of changes in land use. Through these surveys, four factors were extracted as most relevant for affecting rice production and land use: (1) climate conditions, (2) economic environment, (3) rice planting index, and (4) distance from palm oil enterprise estates. When unusual climate conditions were observed across North Sumatra such as in 2006, the rice harvest area substantially decreased. Economic conditions, most notably the price difference between oil palm and rice, which incentivized land use conversion, also existed in common across the province. However, the remaining two factors - rice planting index and the proximity to palm oil mills - varied across regencies, which differentiated the rice farmers' responses.

Secondly, by building upon Van der Eng (2010), which found that rice markets worked to mitigate food deficiencies in areas affected by shortage of rainfall and falling production, the present study considers whether an adaptive function inherently exists in rice markets. To this end, monthly inflation rates of food over the last ten years were analyzed between different locations. Food price was used as an indicator of adaptive responses on the premise that the market, if well integrated, should be able to adapt by providing price signals to direct flows of rice from surplus to deficit areas. Persistent price differences between locations imply weak supply responses to higher prices. This paper targeted the

rice distribution between Surabaya and Kupang, the provincial capitals of East Java and East Nusa Tenggara (*Nusa Tenggara Timur*, NTT), respectively. The above two provinces were chosen as target sites since East Java has a surplus of rice while NTT has a chronic deficit, and according to Varela *et al*. (2012), the rice markets in the two provinces are one of the most strongly integrated pairs in the country. The present study found that the inflation rates are consistently higher in Kupang than Surabaya in January, the lean season in NTT, indicating seasonally weakening supply response to higher prices. The above findings suggest that, when and where seasonal factors are strong, government intervention for rice price stabilization to mitigate climate impacts, if it is centrally operated, is less effective. Instead, a more seasonally and geographically targeted intervention becomes necessary.

Thirdly, this study presents an overview of adaptation for rice production, and evaluates crop insurance as a part of a broader risk management approach. In particular, it examines pilot indemnity insurance under implementation for rice farmers, and the feasibility and scalability of weather index insurance if it would be applied in the same context. East Java was selected as a target province under the study because this is the place where the pilot insurance is being conducted by the government. The validity of the indemnity insurance was considered using historical data on monthly rice harvest failures in the pilot regencies. The feasibility of weather index insurance was analyzed on scatter plots between historical data on rainfall and rice harvest failure by month in the pilot regencies. Locally observed rainfall data was used for this study, since this is the parameter on which weather index insurance is most frequently based. The issue of scalability of index insurance was analyzed on correlation coefficients of rainfall and rice harvest failures by month across all the regencies in the province. This study found that the pilot indemnity insurance is costly. Replacing it with weather index insurance, however, would bring about the problem of a basis risk, a gap between an insured index and the risk it is meant to target, since the rice harvest failures are not only due to a particular weather parameter, but also result from an interaction of multiple factors. It also found that rice harvest failures are more area-dependent than rainfall is in East Java, suggesting that a basis risk would potentially increase as the insured area geographically expands.

The above findings have important policy implications. The literature (Adger *et al.*, 2005; Adger and Vincent, 2005; Osbahr *et al*., 2010; Vincent *et al*., 2013) cautions that whether or not adaptation is successful, is often dependent on scale. In case of farmers, for example, who convert their land use from rice production to oil palm plantation, it may be considered as a good adaptation, as oil palm is more resilient to rainfall variability. The large scale of the conversions, however, is a threat to the food security of the society as a whole. Along with exhibiting a spatial dimension, adaptation also has a temporal dimension. Crop insurance is one of the examples. When farmers purchase insurance, they are able to transfer production risk to the insurer in the short run. However, the risk transfer in itself does not address the underlying problems of climate and socio-economic impacts on rice production.

Unless these problems are addressed by other measures, the risks may continue to increase and become hardly insurable in the long run.

The above observation indicates that government countermeasures may face trade-offs between various adaptation actions, and between adaptation and other development priorities over different spatial and temporal dimensions. It suggests the importance of evaluating particular adaptation actions from different scales to identify potential trade-offs and understand the sustainability of the proposed actions. It also underlines the importance of planning a coherent set of structural and non-structural response measures. In order for the crop failures concerned to be insurable, for example, other adaptation measures including structural responses for strengthening flood control capacity, as discussed in this paper, need to be designed in tandem.

This study also revealed the necessity for further research on the policy, institutional mechanisms and procedures for resolving the above-mentioned trade-offs. In this context, criteria and indicators for assessing and prioritizing the trade-offs need to be developed.

インドネシアにおける米生産・流通への気候及び社会・経済影響とその対応に関する評価

要約

本研究を手掛けるにあたっての大きな関心事は、気候変動及び変化の影響下で、果たしてインドネシアの食料安全保障は確保されるか、という点にある。インドネシアは、世界第 4 位の人口を有し、17,000 以上の島々から構成されることから、国民の食料安全保障の確保は、政府にとって極めて重要かつ困難なテーマである。本論文は、インドネシア国民の大多数の主食である米の確保、特にその生産と流通に焦点を当てる。

本論文の全体的な目的は、インドネシアの食料安全保障に対する気候及び社会･経済影響、ならびに市場及び政府の対応を評価することである。これにあたり、冒頭で、①米生産と流通に関する歴史的・今日的な社会・経済問題、②観測及び予測される気候変動と変化、③気候影響下における上記の社会・経済問題の更なる悪化の状況、④インドネシア政府の近年の対応について概観する。

以上の目的と背景の下、本論文は、次の 3 つの研究項目から構成される。第一に、米生産からパーム油のプランテーションへの土地利用転換における気候及び社会・経済要因を分析するとともに、農民の対応を類別し、異なる対応を生む要因を分析した。右の分析にあたり、北スマトラ州を対象地に選んだが、それは、この地が米とパーム油の双方の大生産地であり、両者の間で土地利用をめぐる関係が問題となっていることによる。一般に入手できるデータに制約があることから、政府関係者や農民とのインタビュー及び関係機関とのグループ会議を通じ、土地利用転換の要因の特定を行い、その結果、①気候条件、②経済環境、③米の作付け回数、④パーム油精油工場との距離の 4 つの要因が抽出された。2006 年に見られたような異常気象の下では、米の収穫面積は大きく減少した。また、経済要因、特に米とパーム油との市場価格の乖離は、米からパーム油への土地利用転換を促進した。これらは州内共通の要因であるが、一方、米の作付け回数、及びパーム油精油工場との距離については、同じ州内でも地域ごとに状況が異なり、そのため農民の対応に違いが生じている。

第二に、降雨量の不足とこれに伴う米生産量の低下が見られた地域において、米市場の働きにより食料不足が緩和されたとの研究成果（Van der Eng, 2010）に基づき、本研究では、米市場に自律的な適応機能が存在するか否かにつき分析を行った。そのため、過去 10 年間にわたる食料の月間インフレ率を異なる地域間で分析した。食料価格を適応機能の指標として活用したが、これは、市場の統合が進んでいれば、価格の調整機能により、米は余剰のある地域から不足する地域に流通し、これにより市場は米不足に適応することができる、その一方で、異なる地域間で価格差が一定期間にわたり解消されないとすれば、それは市場の適応機能が弱い状況を示すとの先述の研究成果に依拠したものである。本研究では、東ジャワと東ヌサテンガラ（NTT）の各州都であるスラバヤ、クパン両市の間の米流通に焦点を当てた。この 2 州を選定したのは、東ジャワが余剰米を抱える一方、NTT が慢性的に米不足の状況にあること、また両州がインドネシアにおいて最も市場の結びつきが強いとの過去の研究成果（Varela *et al*., 2012）によるものである。本研究では、収穫前で米不足のピークを迎える例年

1 月に、スラバヤよりクパンの食料インフレ率が高くなることが明らかになったが、これは市場の適応機能が季節的に弱くなることを示す。この結果は、季節的な要因が強く働く状況の下で、気候影響に対する食料価格安定化のための政府の市場介入が、もし中央で一律的に実施された場合、その効果は限定的になる可能性、及び季節的・地域的な特性を十分に踏まえた介入の必要性を示唆するものである。

第三に、米生産における適応策の全体像を示すとともに、作物保険をより幅広いリスク管理の中に位置づけ、評価を行った。特に、農民向けに試験実施中の実損填補保険につき検討を行うとともに、同じ状況の下で天候インデックス保険を導入した場合の実施可能性、及び実施規模拡大の可能性につき評価を行った。それにあたり、インドネシア政府の試験事業が実施されている東ジャワ州を本研究の対象とし、試験実施中の保険について、州内の事業対象県における米の収穫不良面積に関する過去の月次データを分析し、その妥当性を評価した。また、天候インデックス保険の実施可能性に関し、対象県における米の収穫不良面積及び降雨量の月次データを活用し、散布図の分析を行った。降雨量データを活用したのは、それが、多くの場合、天候インデックス保険においてインデックスの対象とされることによる。天候インデックス保険の実施規模拡大の可能性については、州内すべての県を対象に、降雨量及び米の収穫不良面積の月次データのそれぞれについて県相互の相関係数を算出し、これを比較検討した。これら分析の結果、試験実施中の実損填補保険はコスト高であること、一方で、これに代えて天候インデックス保険を導入した場合には、ベーシス・リスク（補填額と実際の損失との差）の問題を生じることが明らかになった。それは、米の収穫不良が必ずしも特定の気候要因のみではなく、複数の要因が相互に影響し合う中で生じることによる。また、本研究を通じ、東ジャワ州では、降雨量に比較して、米の収穫不良に関する県相互の相関係数が低いことが明らかになったが、これは天候インデックス保険が仮に導入され、その対象地域が広がれば、ベーシス・リスクが更に拡大する可能性を示すものである。

本研究により明らかになった以上の点は、政策面での重要な示唆を与える。適応の成功・不成功は、往々にして評価の尺度によるとの過去の研究成果（Adger *et al.*, 2005; Adger and Vincent, 2005; Osbahr *et al*., 2010; Vincent *et al*., 2013）がある。米生産からパーム油のプランテーションに土地利用転換を行った農家を例にとると、降雨量の変動に対しパーム油は米よりも抵抗力が強いことから、彼らの視点から見れば、土地転換は良い適応と考えられるかもしれない。しかしながら、それが大規模に行われると、社会全体から見れば、食料安全保障への脅威となる。適応は、こうした空間的な尺度だけでなく、時間的な尺度から見ることもできる。作物保険はその一例である。保険を購入することにより、短期的に見れば、農民はリスクを保険業者に転嫁することができる。しかしながら、リスクを転嫁しても、米生産への気候及び経済・社会影響に関する根本的な問題に取り組んだことにはならない。他の対策を通じて、こうした問題に取り組まない限り、長期的には、リスクの増大に伴い、当該リスクがもはや保険の対象となり得なくなる恐れがある。

以上の点は、空間的・時間的に異なる視点から見れば、適応策相互、及び適応策と他の開発優先事項の間でトレードオフが生じる可能性を示す。また、このことは、適応策を違った視点から評価し、トレードオフの可能性及び当該対策の持続可能性を検討することの重要性、

更には、構造的・非構造的な対応の双方から成る一貫性のある対策立案の必要性を示す。米の収穫不良が保険の対象となり得るためには、治水容量の増大に係る構造的な対策等を含む他の適応策を併せて立案する必要があることが本論文で指摘されたが、これは一例である。

最後に、本研究を通じ、今後の研究課題もまた明らかとなった。すなわち、上記のトレードオフを解決するために必要な政策・制度上の仕組みと手続き、更には、こうしたトレードオフを評価し、対策の優先付けを行うための基準や指標の開発に関し、今後の研究が求められる。

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Masato Kawanishi
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List of Abbreviations

ADB	Asian Development Bank
BAPPEDA	Provincial Development Planning Agency (*Badan Perencanaan Pembangunan Daerah*)
BAPPENAS	National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional*)
BMKG	Agency for Meteorology, Climatology and Geophysics (*Badan Meteorologi, Klimatologi, dan Geofisika*)
BPS	Central Statistics Agency (*Badan Pusat Statistik*)
BULOG	Bureau of Logistics (*Badan Ursan Logistik*)
EL	Elevation level
ENSO	El Nino-Southern Oscillation
DWT	Dead weight ton
FAO	Food and Agriculture Organization
GCM	General circulation model
GDP	Gross domestic product
IOD	Indian Ocean dipole
ITCZ	Inter-tropical convergence zone
JICA	Japan International Cooperation Agency
LPEM-FEUI	Institute of Economic and Social Research, Faculty of Economics, University of Indonesia (*Lembaga Penyelidikan Ekonomi dan Masyarakat, Fakultas Ekonomi, Universitas Indonesia*)
LPI	Logistics Performance Index
MoA	Ministry of Agriculture
NTT	East Nusa Tenggara (*Nusa Tenggara Timur*)
OECD	Organisation for Economic Co-operation and Development
PTPN	State-owned plantation company (*PT Perkebunan Nusantara*)
PU	Ministry of Public Works (*Kementerian Pekerjaan Umum*)
RAN-API	National Action Plan for Climate Change Adaptation (*Rencana Aksi Nasional untuk Adaptasi Perubahan Iklim*)
R&D	Research and development
SST	Sea surface temperature
SUSENAS	National Socio-Economic Survey (*Survei Social Ekonomi Nasional*)
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1. Objective

This thesis arises from a concern about food security in Indonesia under the impacts of climate variability and change. Food security is a highly important and complex task for the government as Indonesia is the world's fourth most populous country with more than 17,000 islands. The present study targets rice, the staple food of most of her population, and focuses on its availability, in particular production and distribution.

Food security is defined by the Food and Agriculture Organization (FAO) as the situation where 'all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996). Food security has three major components: availability, access and utilization, as indicated in Fig. 1.1. Food availability refers to the amount, type and quality of food to consume. Access to food is the ability to obtain access to the type, quality, and quantity of food required, while food utilization is individual or household capacity to consume and benefit from food. Out of these three components, food availability, more specifically the amount of food to consume, is the concern of this thesis. While food availability is attributed to three elements: production, distribution and exchange, the present study focuses on rice production and distribution. According to Ericksen *et al*. (2010), production refers to how much of food to be consumed is available through local production, while distribution refers to how food for consumption is physically moved to be available, in what form, when and to whom.

A variety of socio-economic problems affect rice production in Indonesia. These include the decrease in cropland in Java as well as decreasing rate of expansion in cropland outside Java, mostly resulting from land use conversion from rice production to more profitable opportunities, such as oil palm plantation. The decreasing growth in yields is another problem, which is associated with the decline of public investments in development of irrigation as well as government support for provision of seeds and fertilizers.

Rice distribution is critical for food security in Indonesia. Even if self-sufficiency of rice may be achieved in the national aggregate, some provinces, such as East Nusa Tenggara (*Nusa Tenggara Timur*, NTT), still have a deficit, relying upon others for supply. This is associated with the socio-economic disparity between provinces, which is further complicated by the sheer size and heterogeneity of the country.

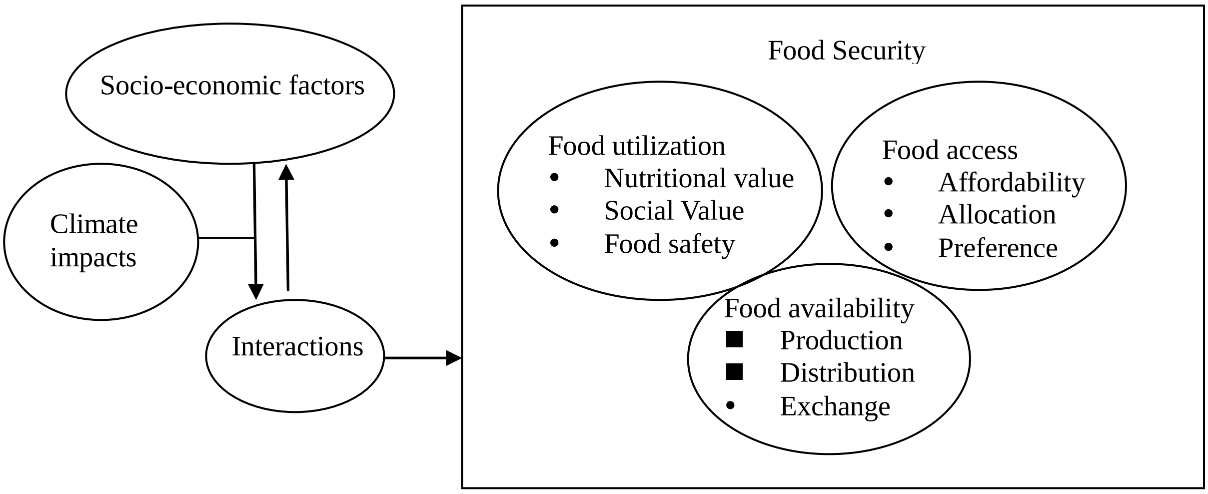

Fig. 1.1 Concept of food security (cited with modifications from Ericksen *et al*., 2010)

The overall objective of this study is to assess climate and socio-economic impacts on food security, and evaluate market and policy responses in Indonesia. In order to achieve this objective, the present study starts in Chapter 2 with an overview of the following issues: (1) the historical and current socio-economic problems concerning rice production and distribution, (2) the observed and projected climate variability and change, (3) the way that climate impacts exacerbate the existing socio-economic problems, and (4) the recent policy responses of the Indonesian government.

With the above objective and background, this study has three research components. Firstly, Chapter 3 examines the combination of climate and socio-economic factors that have contributed to land use conversion from rice production to oil palm plantation. It also identifies types of farmers' responses, and the variables that differentiate them. North Sumatra is selected as the target area of this study because it is a significant producer of both rice and palm oil, as shown in Table 1.1, where competition for land use is fierce.

Secondly, by building upon Van der Eng (2010), which found that the rice markets worked to mitigate food deficiencies in areas affected by shortage of rainfall and falling production, Chapter 4 examines whether an adaptive function inherently exists in rice markets. To this end, monthly inflation rates of food over the last ten years are analyzed between different locations. Food price is used as an indicator of adaptive responses on the premise that the market, if well integrated, should be able to adapt by providing price signals to direct flows of rice from surplus to deficit areas. Persistent price differences between locations imply weak supply responses to higher prices. This paper targets the rice distribution between Surabaya and Kupang, the provincial capitals of East Java and NTT, respectively. The above two provinces are chosen as target sites since East Java has a surplus of rice while NTT has a chronic deficit due to a short rainy season and a poor irrigation infrastructure. Besides, according to

Varela *et al*. (2012), the rice markets in the two provinces are one of the most strongly integrated pairs in the country.

Thirdly, Chapter 5 presents an overview of adaptation for rice production, and evaluates crop insurance as a part of a broader risk management approach. In particular, it examines pilot indemnity insurance under implementation for rice farmers, and the feasibility and scalability of weather index insurance if it would be applied in the same context. East Java is selected as a target province for this study because this is the place where the pilot insurance is being conducted by the government.

The thesis ends in Chapter 6 with a conclusion and identification of further research needs.

Table 1.1 Production of paddy (*) and oil palm by province (BPS, 2012)

Province	Provincial capital	Wetland paddy area (thousand ha), 2010	Paddy production (thousand ton), 2011	Planted area of oil palm (thousand ha), 2010	Production of oil palm (thousand ton), 2010	Population density (population per km^2), 2010
Aceh	Bandah Aceh	315	1,773	325	617	78
North Sumatra	Medan	469	3,607	1,140	3,900	178
West Sumatra	Padang	230	2,280	377	986	115
Riau	Pekanbaru	116	536	1,780	5,496	64
Riau Islands	Tanjung Pinang	-	-	9	14	205
Jambi	Jambi	112	647	544	1,644	62
South Sumatra	Palembang	611	3,385	862	2,543	81
Bangka Belitung Islands	Pangkal Pinang	4	15	176	490	74
Bengkulu	Bangkulu	93	503	298	796	86
Lampung	Bandar Lampung	345	2,941	141	406	220
Jakarta	Jakarta	1	10	-	-	14,469
West Java	Bandung	930	11,634	9	16	1,217
Banten	Serang	197	1,950	16	26	1,100
Central Java	Semarang	962	9,392	-	-	987
Yogyakarta	Yogyakarta	56	843	-	-	1,104
East Java	Surabaya	1,107	10,577	-	-	784
Bali	Denpasar	81	858	-	-	673
West Nusa Tenggara	Mataram	239	2,067	-	-	242
East Nusa Tenggara	Kupang	142	591	-	-	96
West Kalimantan	Pontianak	307	1,373	667	1,427	30
Central Kalimantan	Palangka Raya	176	610	949	1,725	14
South Kalimantan	Banjarmasin	436	2,038	428	1,049	94
East Kalimantan	Samarinda	83	553	542	700	17
North Sulawesi	Manado	53	596	-	-	164
Gorontalo	Gorontalo	30	274	-	-	92
Central Sulawesi	Palu	136	1,042	65	146	43
South Sulawesi	Makassar	572	4,512	19	35	172
West Sulawesi	Mamuju	59	366	95	264	69
Southeast Sulawesi	Kendari	83	492	38	15	59
Maluku	Ambon	11	87	-	-	33
North Maluku	Ternate	9	61	-	-	32
Papua	Jayapura	28	115	45	136	9
West Papua	Manokwari	8	29	25	66	8
	Total	8,003	65,757	8,549	22,497	124

Note:

(*) Paddy becomes rice after removal of husk by threshing. The term ‘paddy’ is used in this thesis where it is appropriate to differentiate paddy from rice. The official conversion rates from wet paddy to dry un-husked paddy and from dry un-husked paddy to rice are 86.02% and 62.74% respectively in Indonesia.

1.2. Data and methods

As far as it was available, local statistical data was collected and analyzed for each chapter. When quantitative data was insufficient, data from other sources, such as interviews and meetings with the government, was utilized as supplemental evidence. The detailed description on data and methods for each chapter is given below.

For Chapter 3, the availability of statistical data on the causes for land use change in North Sumatra was limited. To overcome the limitation, interviews with government officials and farmers, as well as focused group meetings with relevant agencies were conducted. The minutes of meetings were recorded in BAPPEDA North Sumatra (2011). North Sumatra was visited most intensively from August to November 2011. The government agencies that were interviewed included the Agricultural Office, the Agency for Meteorology, Climatology and Geophysics (*Badan Meteorologi, Klimatologi, dan Geofisika*, BMKG), the Bureau of Logistics (*Badan Ursan Logistik*, BULOG), and the Food Security Agency as well as the Provincial Development Planning Agency (*Badan Perencanaan Pembangunan Daerah*, BAPPEDA). The interviews with farmers took place at several locations in Simalungun and its neighboring regencies (*kabupaten*). At first, focus group meetings at the provincial government were conducted to obtain an understanding on the recent changes in land use and list their potential causes. These included climate conditions; economic environment, such as price differences between rice and oil palm; a rice planting index associated with access to water; distance from mills at palm oil enterprise estates; lack of enforcement of land use regulations; and lack of policy coordination. Semi-structured interviews with government official and farmers were then conducted on a list of questions to ask them to cite the causes which they consider as most relevant. Through these surveys, four factors were extracted as relevant for affecting rice production and land use: (1) climate conditions, (2) economic environment, (3) a rice planting index, and (4) distance from palm oil enterprise estates. They were further validated with literature and other sources of evidence, which included statistical data collected from the Central Statistics Agency (*Badan Pusat Statistik*, BPS), BMKG, and the Agriculture Office of North Sumatra. These sets of data were utilized for time series analyses from 2000 to 2009 concerning rice production and land use conversion; time series analyses of annual rainfall from 1991 to 2010 and monthly rainfall from 1997 to 2010 in Medan; their comparison with rice harvest area in the province from 2000 to 2010; a time series analysis of monthly farmers' net terms of trade by crop type from 2008 to 2010; and a time series analysis of oil palm plantation area divided by rice harvest area at the regency level from 2001 to 2010.

In Chapter 4, monthly inflation rates of food in Surabaya and Kupang from 2002 to 2010, with the total number of pairs being 108, were utilized to study adaptive responses of distribution between these two cities. Data on monthly inflation rates specifically for rice in these two cities was not available for the present study. Instead, data on monthly inflation rates of food items, available from BPS, was utilized. Cereals, in particular rice, are the dominant item in this data, even if its share is not clearly specified by BPS. A cross-correlation analysis was conducted on the monthly inflation rates between the two cities. The relationship between these two data sets was then analyzed in the scatter diagram. A seasonal change in the ability to supply rice in East Java was gauged by the data on monthly rice stock at BULOG East Java, while that in the purchasing power in NTT was measured by the data on monthly net farmers' terms of trade, available from BPS NTT. As sea transport is a dominant mode for transportation of food between the two cities, the impact of wind velocity on food price differences between them was also analyzed in the scatter diagram, using data on monthly wind velocity in Surabaya, available from BPS. The corresponding data in Kupang was only available for very recent years. Other potentially relevant data, such as the number of navigational warnings and ship accidents, was only available on an annual basis for this study. Kupang was visited in January 2013 to obtain a general understanding of its climate and socio-economic conditions.

In Chapter 5, the present study evaluated the pilot insurance conducted by the Ministry of Agriculture (MoA), starting with the review of Pasaribu and Sudijanto (2013), who were commissioned by the project 'Capacity Development for Climate Change Strategies in Indonesia', funded by Japan International Cooperation Agency (JICA), to make a rapid assessment of the above pilot activity. The pilot regencies, Tuban and Gresik in East Java, were also visited in April 2013. The potential problem of adverse selection was considered using historical data on monthly rice harvest failures in the pilot regencies, which was available from BPS East Java. The feasibility of weather index insurance in the same context as being piloted above was analyzed on scatter plots between historical data on rainfall and rice harvest failure by month from 2000 to 2010 in the pilot regencies. Both datasets were available from BMKG and BPS East Java for this study. Locally observed rainfall data was used for this study, since this is the parameter on which weather index insurance is most frequently based. The issue of scalability of index insurance was analyzed by comparing the correlation coefficients of rice harvest failures on one hand and rainfall amounts on the other, both on a monthly basis, across the regencies in East Java. The comparison was made in terms of distributions of the correlation coefficients of 406 pairs of regencies. The data on rice harvest failures was available at BPS East Java from 2000 to 2010. Monthly rainfall data for all of the regencies was available at BPS East Java, however, only from 2001 to 2005 for the present study. The assessment of insurability of the pilot insurance was made in reference to the criteria developed by Berliner (1985).

Many pieces of data used for the present study were not accessible from websites but obtained only by visits to the providing offices in person. Usually, they were only available in Indonesian language, in which cases translation was arranged. In addition to the difficulty of access to data, the provided data is often not complete and the quality of data is problematic.

In particular, Indonesian rice production and consumption data is controversial. According to Rosner and McCulloch (2008), rice harvest area is estimated each month by agricultural field agents (*mantri tani*), employed by local governments, using an 'eye estimate' approach. Local records and reports from farmers groups, village chiefs and other local officials provide baseline information on total agricultural area in each district. The *mantri tani* combine these records on land area with their own observations of the cropping pattern each month to report harvested area. To assess the accuracy of the eye estimates, BPS undertook a large survey of rice harvest area in Java using a household approach (BPS, 1998) and discovered that the eye estimate method had over-estimated rice harvest area by 17%.

The main source of data on rice consumption, on the other hand, is the National Socio-Economic Survey (*Survei Social Ekonomi Nasional*, SUSENAS), which also has some weaknesses. According to Rosner and McCulloch (2008), SUSENAS does not directly measure the quantity of rice that households consume outside home, for example, in road-side food stalls (*warung*) and restaurants. In addition, SUSENAS does not include rice consumed by the food processing industry, such as for rice noodles. As a result of these weaknesses, SUSENAS under-estimates true rice consumption.

One of the methodological choices to adjust the above-described over-estimates of rice production and under-estimates of consumption, as presented by Rosner and McCulloch (2008), is to adjust the production figure downwards by 17%, while assuming the amounts of rice consumed outside home and used by industry to be 10.8% and 9.6% of the total consumption respectively. These adjustment ratios are adopted in this thesis, as shown in Table 2.7.

When data on rice production and harvested area is used without any adjustments in this thesis, it is mainly intended to analyze the changes over time. In this respect, based on international experience, Rosner and McCulloch (2008) indicate that eye estimates can be relatively accurate at measuring changes in harvested area, even though they are not accurate at measuring the total harvested area.

This thesis confirmed the validity of data in conjunction with multiple sources of evidence, including interviews and focus group discussions. Other sources such as archival records and newspaper articles were also taken as supplementary materials.

2. Climate and Socio-economic Impacts and Responses for Rice Production and Distribution: Overview

2.1. Status and trend of agriculture in Indonesia

According to BPS, Indonesia lies on the equator line between 6°08’ North and 11°15’ South latitude, and is located between 94°45’ and 141°05’ East longitude (BPS, 2012). It has 33 provinces as of 2012, spreading over five main islands and four archipelagos, namely the Islands of Sumatra, Java, Kalimantan, Sulawesi and Papua, and the Archipelagos of Riau, Bangka Belitung, Nusa Tenggara and Maluku (Fig. 2.1).

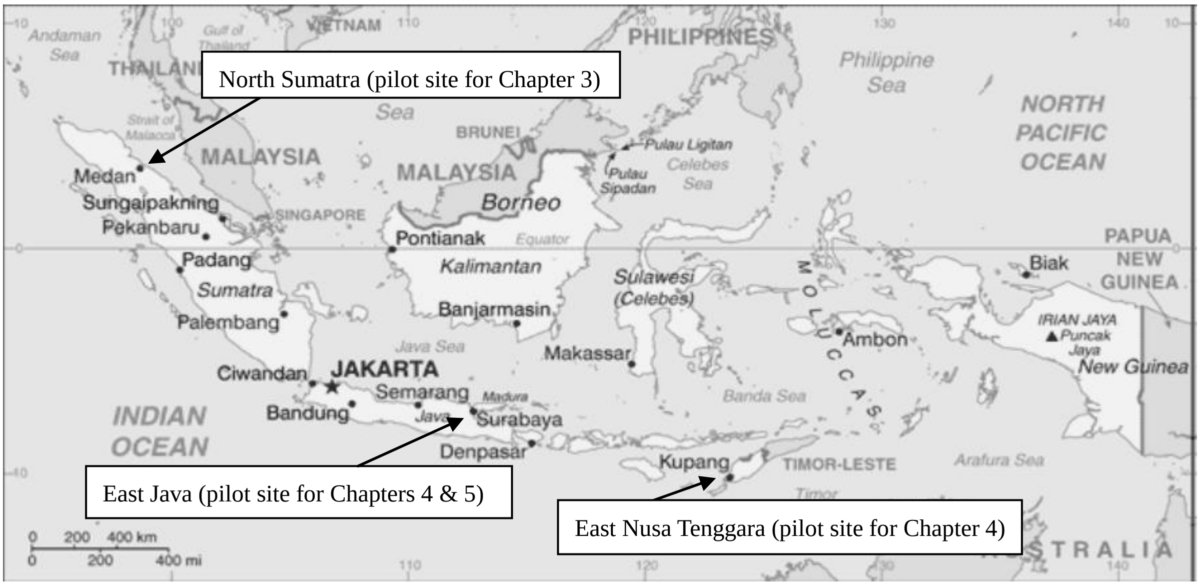

Fig. 2.1 Map of Indonesia (cited from Wicke *et al*., 2008)

Indonesia is the world’s fourth most populous country after China, India and the USA, with the population of 240 million in 2010. According to the World Bank (2013a), it is ranked at 16th in the world in terms of gross domestic product (GDP) (Fig. 2.2) and the world’s fifth largest agricultural producer after China, India, the USA and Brazil. It is also the third largest rice producer and consumer after China and India, as well as the world’s top producer and exporter of oil palm. Rice is Indonesia’s single most important commodity, and for most of her population, it is the staple food. According to FAO (2013), rice is the top commodity for consumption with its milled equivalent amount of 1,259 kcal/capita/day in 2009, which is followed far behind by maize with the amount of 259 kcal/capita/day.

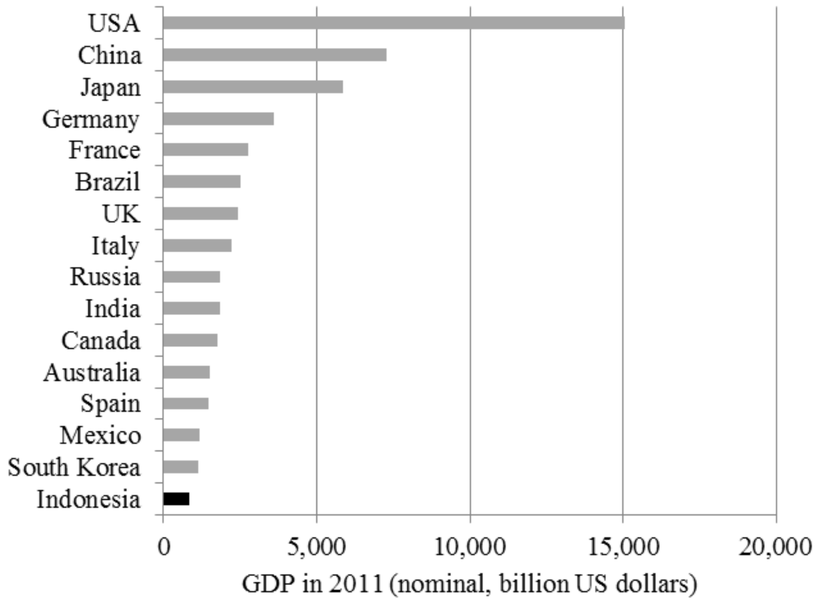

Fig. 2.2 GDP: International comparison (World Bank, 2013a)

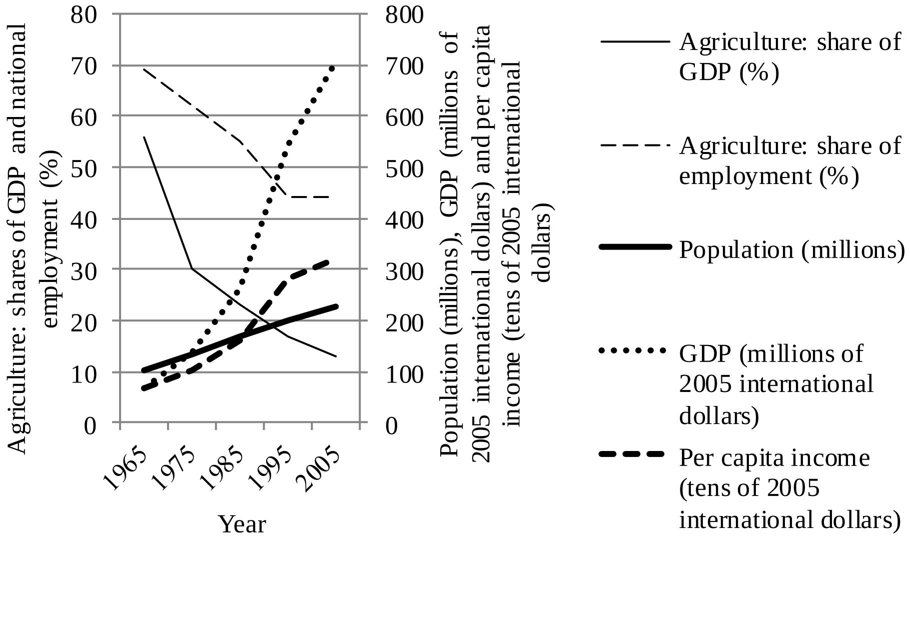

Fig. 2.3 Structural changes in Indonesian economy from 1965 to 2005 (World Bank, 2013a)

The extent of structural changes in the Indonesian economy between 1965 and 2005 is illustrated in Fig. 2.3. According to the World Bank (2013a), while the population more than doubled from 107 million to 227 million during this period, the real GDP increased by more than ten times from $69 million to $708 million (2005 international dollars). With the achievement of a per capita income of $3,209 by 2005, increasing by more than five times from $663 in 1965, Indonesia was classified by the World Bank as a lower-middle-income country. Substantial changes have occurred in the sectoral shares of GDP, with agriculture's share falling from 56% to 13%. Its share of total employment also declined from 69% to 44%. As discussed by Fuglie (2010), however, it remains the dominant sector of employment, particularly in rural areas.

Broad trends in the agricultural sector are shown in Table 2.1. Despite the declining share of the GDP, the agricultural GDP in the real term (2005 international dollars) nearly tripled from $36.0 billion during 1961-65 to $95.3 billion during 2001-05. Food crops, particularly rice, constitute the largest component of agricultural output. The rice output has been increasing, but its growth rate has been declining. The rice output per capita had increased solidly until the early 1980s. However, its growth started to slow down in the late 1980s and plateaued, even decreasing, since the early 1990s. Rice yield has also reached a plateau since 1990s after a significant growth in the previous decades. On the other hand, a tremendous increase in outputs of estate crops, in particular oil palm, has been achieved. Oil palm has rapidly become an important component of Indonesia's agricultural sector in recent years. As observed in Table 2.2, rice had been the most produced commodity in terms of quantity until the mid-1990s. By the mid-2000s, however, it was replaced by oil palm, which had not been even among the top five commodities until the mid-1970s. This is associated with changes in the comparative prices of rice and oil palm, as illustrated in Fig. 2.4, where a stagnant price trend of rice was observed until the mid-2000s while palm oil prices moved consistently at higher levels.

Table 2.1 also presents the trend in agricultural inputs. While a consistent increase in total cropland area is attained, cropland in Java has been decreasing and all the expansion has been taking place outside Java. The rate of increase was most substantial from 1970-75 to 1980-85, and the expansion continues up to now in many of parts of the country where previously forested areas were converted to cropland. The share of irrigated cropland had increased towards the early 1990s, but its growth has virtually stopped since then. Similarly, the growth in inputs of fertilizers has recently diminished. Labor input, on the other hand, has been modestly but consistently increasing, indicating the continued role of agriculture to be a source of income and employment opportunities in rural areas.

Table 2.1 Agricultural production and input use in Indonesia (the numbers below represent the annual average over the respective periods, and those in parentheses represent growth rates in percentage) (original data from BPS, various years; FAO, 2013)

Year	1961-65	1971-75	1981-85	1991-95	2001-05
Agricultural GDP (billions of 2005 international dollars) *	36.0	42.3	55.3	83.6	95.3
		(17.5)	(30.7)	(51.2)	(14.0)
Rice output (millions of tons of paddy) **	12.4	21.2	35.8	47.5	52.5
		(71.0)	(68.9)	(32.7)	(10.5)
Rice output per capita (kilograms of milled rice) **	97.6	110.5	154.6	165.0	157.6
		(13.2)	(39.9)	(6.7)	(-4.5)
Rice yield (ton/ha) **	1.8	2.5	3.8	4.4	4.5
		(38.9)	(52.0)	(15.8)	(2.3)
Estate crop output (millions of tons of rice equivalent) **	5.2	12.8	15.2	20.3	32.0
		(146.2)	(18.8)	(33.6)	(57.6)
Oil palm **	0.1	0.2	0.5	1.8	10.3
		(100.0)	(150.0)	(260.0)	(472.2)
Rubber **	1.6	2.1	2.3	3.9	5.5
		(31.3)	9.5)	(69.9)	(41.0)
Agricultural inputs					
Cropland (million hectare) *	17.6	18.9	25.9	32.3	38.5
		(7.4)	(37.0)	(24.7)	(19.2)
Java *	9.0	8.8	7.0	7.1	7.0
		(-2.2)	(-20.5)	(1.4)	(-1.4)
Outside Java *	8.6	10.0	19.6	25.1	31.5
		(16.3)	(96.0)	(28.1)	(25.5)
Irrigated cropland (%) *	15.2	16.2	18.1	22.7	23.2
		(6.6)	(11.7)	(25.4)	(2.2)
Fertilizer (kilograms/ha) **	6.9	22.7	64.3	76.3	85.6
		(229.0)	(183.3)	(18.7)	(12.2)
Labor (million workers) **	28.6	31.7	37.7	46.1	50.7
		(10.8)	(18.9)	(22.3)	(10.0)

Notes:
1) (*) Original data from BPS (various years)
2) (**) Original data from FAO (2013)

Table 2.2 Five most produced commodities in terms of quantity in Indonesia (FAO, 2013)

	1965	1975	1985	1995	2005
1	rice (paddy)	rice (paddy)	rice (paddy)	rice (paddy)	oil palm
2	cassava	sugar cane	sugar cane	sugar cane	rice (paddy)
3	sugar cane	cassava	cassava	oil palm	sugar cane
4	coconuts	coconuts	coconuts	cassava	cassava
5	sweet potatoes	maize	oil palm	coconuts	coconuts

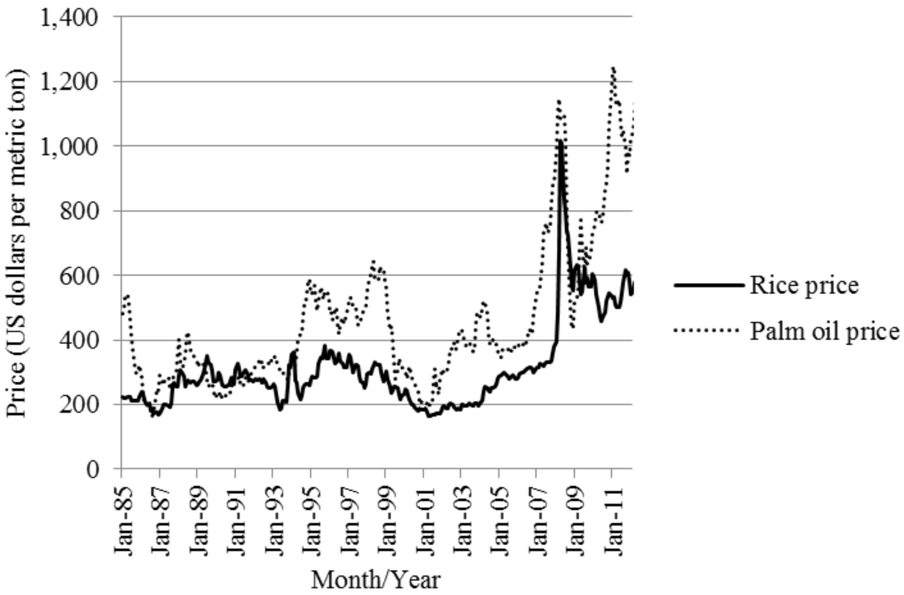

Fig. 2.4 Monthly market price changes of rice and palm oil (Index Mundi, 2013)

2.2. Status and trend of paddy production in Indonesia

While the previous section gave an overview of agriculture in Indonesia, this section focuses on broad trends in paddy production. The amount of paddy production is a product of harvested area and yield, while harvested area is cropland area times cropping intensity. Thus, paddy production is a product of three factors: cropland area, cropping intensity and yield. Table 2.3 compares these factors between 1981-85 and 1991-95. Paddy production grew by 4.82% during 1981-85, mainly due to the enhancement in cropping intensity and yield both in and outside Java. The area of wet paddy field, on the other hand, decreased in Java, while increasing modestly outside Java. The growth rate in paddy production during 1991-95 was 2.37%, lower than the previous period, receiving almost equal contributions by the three factors nationwide. The growth rates in cropping intensity and yield declined both in and outside Java, however. The area of wet paddy field decreased in Java for two consecutive periods. Expansion outside Java was the only factor where the contribution was stronger than the previous period. Thus, with the diminishing growth in cropping intensity and yield as well as the consistent reduction of paddy field in Java, the increase in national paddy production became more dependent on the expansion of paddy field outside Java during 1991-95.

Table 2.3 Sources of growth of wetland paddy production in Indonesia (in percentage per annum) (Simatupang and Timmer, 2008)

		1981-85	1991-95
Java	Wet paddy field	-0.32	-0.42
	Cropping intensity	1.89	0.88
	Yield	2.80	1.37
	Total	4.37	1.83
Outside Java	Wet paddy field	0.74	1.46
	Cropping intensity	2.23	1.32
	Yield	2.66	0.38
	Total	5.63	3.16
Indonesia	Wet paddy field	0.22	0.70
	Cropping intensity	1.94	0.88
	Yield	2.66	0.79
	Total	4.82	2.37

Table 2.4 shows, however, that the paddy area outside Java decreased by the early 2000s, while the growth of estate plantation area in the outer islands continued to accelerate. The paddy area declined in Java for three consecutive periods. Outside Java, after increasing from 1981-85 to 1991-95, it decreased from 1991-95 to 2001-04. On the other hand, cropland for estate plantation has been expanding substantially outside Java throughout the periods. Estate plantation area more than doubled from 1981-85 to 2001-04, while the area of paddy field increased only slightly nationwide. Figure 2.5 illustrates the rapid expansion of cropland in the outer islands along with its decline in Java. It also depicts the corresponding acceleration in growth of oil palm production along with a diminishing growth of paddy production.

Table 2.4 Trend in arable land use in Indonesia (the numbers below are expressed in thousand hectares, while those in parentheses represent growth rates, in percentage, from the previous period) (Simatupang and Timmer, 2008)

		1981-85	1991-95	2001-04
Java	Wet paddy field	3,466	3,407	3,280
			(-1.7)	(-3.7)
	Estate plantation	597	628	655
			(5.2)	(4.3)
	Arable land (total)	7,423	7,287	7,314
			(-1.8)	(0.4)
Outside Java	Wet paddy field	4,034	5,000	4,602
			(23.9)	(-8.0)
	Estate plantation	7,898	11,799	17,276
			(49.4)	(46.4)
	Arable land (total)	33,122	35,226	45,685
			(6.4)	(29.7)
Indonesia	Wet paddy field	7,500	8,406	7,882
			(12.1)	(-6.2)
	Estate plantation	8,495	12,427	17,932
			(46.3)	(44.3)
	Arable land (total)	40,545	42,835	52,999
			(5.6)	(23.7)

According to Fuglie (2010), the growth in yield accounted for more than two-thirds of the total growth in paddy production over most of the period of 1961-2007, with the growth in harvested area accounting for the other third. The contribution of yield has been reduced since the early 1990s, as illustrated in Fig. 2.6. The declining rate of yield growth is largely explained by diminishing rate of growth in agricultural inputs. This is attributed by Fuglie (2010) and Simatupang and Timmer (2008) to the reductions of public investments in irrigation, subsidies for fertilizers, and funding for research and development (R&D) on high-yield varieties since the 1990s.

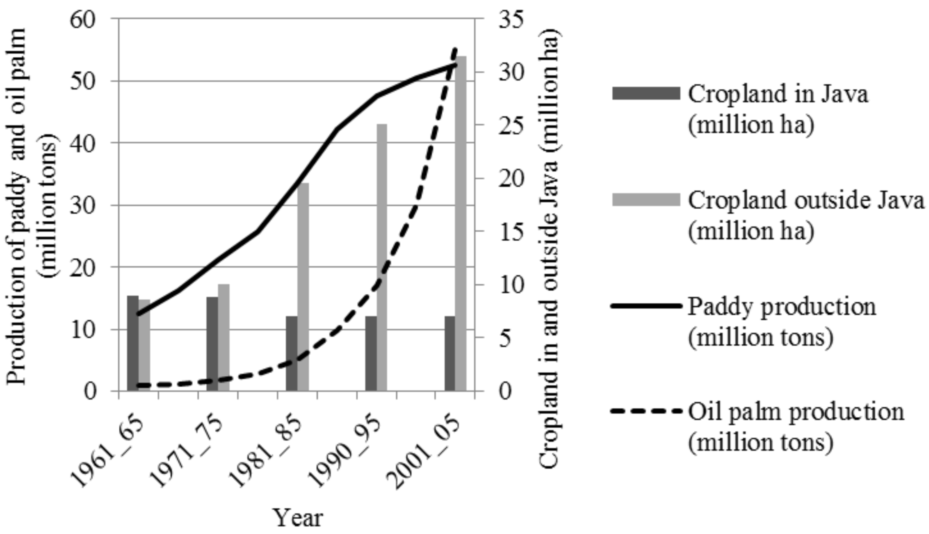

Fig. 2.5 Five-year average trend from 1961 to 2005 in cropland areas, paddy and oil palm production in Indonesia (original data from FAO, 2013; Fuglie, 2010)

Figure 2.6 also depicts the declining contribution of harvested area since the late 1990s. It shows that the amount of paddy production tends to move in tandem with harvested area, with its year-by-year change attributable to a change in cropping intensity rather than cropland area.

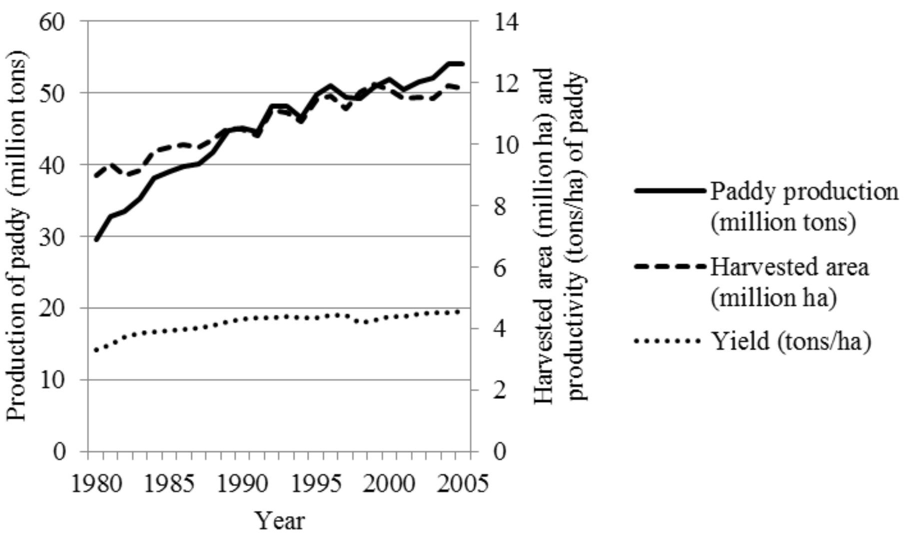

Fig. 2.6 Trend from 1980 to 2005 in paddy production, harvested area and yield in Indonesia (BPS, various years)

Technical irrigation is the key to increasing yield and cropping intensity. This is especially true for high-yield rice and other food crops that require continuous water availability for a good harvest. As documented by Simatupang and Timmer (2008), huge investment in irrigation development was one of the key factors explaining the rapid expansion of rice and other food crop production in the late 1970s and early 1980s. Since the mid-1980s, however, irrigation development and maintenance have been slowing down, contributing to declining rice production. In particular, government spending on irrigation fell drastically during the years 1987-90. After a short rebound it fell again in 1998, and has increased little since then, resulting in degradation of irrigation systems. According to Simatupang and Timmer (2008), about 22% of canals, serving some 6.8 million ha of irrigated cropland, are damaged, including 5% that are severely damaged, due to a lack of maintenance associated with the reduction of funding. Other negative factors include sedimentation associated with forest destruction as well as natural disasters.

As Fuglie (2010) described, the adoption of modern varieties and fertilizers also played an important role in securing higher yields of rice during the 1970s and 1980s. However, this source of growth also started to stagnate by the early 1990s. Fertilizer use increased by 11% per year during 1961-1980, when high-yielding, fertilizer-responsive varieties of rice were widely adopted and the government introduced subsidies for fertilizers and pesticides. The level of fertilizer subsidy, however, was reduced by as much as 50% from the mid-1970s to the mid-1980s, but then gradually declined and ended in 1999, although subsequently it was reintroduced but at a relatively modest level. As reported by the Organisation for Economic Co-operation and Development (OECD) (2012), fertilizer application rates vary across Indonesia’s regions due to differences in soil characteristics presenting different nutrient imbalance and deficiencies, in crop production structure, as well as in market access and infrastructure for transporting inputs. For example, fertilizer application rate reached 285 kg/ha of cropland in Java in 2000. This compares with 117 kg/ha in Sumatra and 98 kg/ha in Nusa Tenggara.

2.3. Policy trend in rice production in Indonesia

Table 2.5 summarizes a policy trend relating to rice production since the 1960s, which includes investments in irrigation infrastructure and agricultural R&D leading to improved varieties of rice as well as subsidies for fertilizers.

As documented by the Asian Development Bank (ADB) (2006), under the colonial regime, agriculture was geared toward production of tropical export crops, such as sugarcane, rubber and tea, while the food crop sector suffered from neglect. After independence, Indonesia inherited a stagnant, low-productivity food-crop sector. The inability to produce enough food for the population was a major challenge of the new government. As self-sufficiency of food, predominantly rice, became a key policy goal, increasing domestic food production became a national priority.

With the boom in world oil prices that commenced in 1973, the government was able to make huge investments to enhance rice production, including irrigation system rehabilitation and expansion. Publicly funded R&D also created new pest-resistant and higher-yield varieties, and as a result rice production accelerated rapidly from about 1977 until 1982. In the meantime, the government initiated major programs to expand estate crop production, especially in sparsely populated outer islands of Sumatra, Kalimantan, Sulawesi and Papua. A ‘transmigration’ program resettled farm families from densely populated Java to these regions (Fuglie, 2010).

Although self-sufficiency of rice was achieved in 1984, this was short-lived. The expensive government program was difficult to sustain following the end of the oil boom in the early 1980s and the dramatic decline in world oil prices in 1986. Fertilizer prices were gradually increased in order to reduce the unaffordable large budget subsidy that had been needed to achieve self-sufficiency. In the meantime, the price of rice in world markets stagnated since the mid-1980s, as depicted in Fig. 2.4, because of the widespread adoption of green revolution technology in rice-producing countries, and much of this decline was gradually passed through to Indonesian farmers after the mid-1980s. Consequently, farmer profitability was squeezed from both sides (Simatupang and Timmer, 2008)

In relation to irrigation, the Law 7/2004 on Water Resources gave local communities a greater responsibility in the management of the irrigation system. The responsibility for different parts of the irrigation system is split between the public and private sectors. As described by OECD (2012), the public sector is responsible for building, operating and maintaining the main irrigation network, namely the primary (dams, reservoirs, etc.) and secondary (rivers, channels, canals, etc.) systems that bring the water to the farm. Farmers, through water user associations, are responsible for operation and maintenance of tertiary systems, such as irrigation channels that flow through farmlands. The above-mentioned public responsibilities are shared across three different levels of government according to the size of the command area and cross-boundary occurrence. The central government, through the Ministry of Public Works (*Kementerian Pekerjaan Umum*, PU), is responsible for the main network in strategic basins and irrigation systems larger than 3,000 ha or cross-provincial systems. The provincial governments have jurisdiction over the management of the main network with a command area of between 1,000 and 3,000 ha, and across regency boundaries. Finally, the regency governments manage irrigation systems smaller than 1,000 ha. The coordination among various actors across the different levels of governance remains a challenge for management of the irrigation system.

Table 2.5 Policy trend in rice production in Indonesia (with reference to Fuglie, 2010; Simatupang and Timmer, 2008)

	1961-70	1971-80	1981-90	1991-2000	2001-date
Policy background	- Economic instability under Sukarno's guided democracy	- Early period of Suharto's regime - High priority on agriculture and food security - Using revenues from oil boom	- Trade and fiscal imbalance leading to policy focus on export-led industry	- Severe economic contraction and political instability caused by the financial crises of 1997-98	- Liberalized agricultural policy with comparative advantage towards export crops, such as oil palm
Characteristics of rice production	- Starting to grow from a low level	- Significant growth	- Starting to slow down	- Stagnation	- Limited recovery
Intensification		- Public investments in irrigation - Subsidies for agricultural inputs (fertilizers, etc.)	- Government support beginning to wane	- Sharp contraction of investments and subsidies	
Extensification		- Transmigration policy with the expansion of cropland outside Java		- Expansion of cropland as a main engine of growth	

2.4. Rice distribution in Indonesia

As documented by OECD (2012) and Ariga and Kitano (2000), around 70% of rice produced is retained as farmers' own household consumption, while the remaining 30% is sold through two channels: one private, and the other run by the government. The private channel accounts for roughly 80% of the total rice traded, and the government for the remaining 20%. Not being obliged to sell rice through the government channel, famers sell it to private collectors or millers when the purchase price in the private sector is higher. The government-run channel is managed by BULOG under the Ministry of Trade, which performs the following three tasks. Firstly, BULOG is responsible for distributing rice to poor households through the so-called 'Rice for the Poor' program. To deliver rice to rural areas under this government program, BULOG operates more than 50,000 distribution points throughout Indonesia. Secondly, BULOG has a function of releasing rice onto the open market to stabilize retail prices of rice. Finally, it is also responsible for management of the government rice reserve in anticipation of emergency situations caused by natural disasters or climatic events. BULOG imports rice if domestically-procured rice is insufficient to perform these three functions adequately.

Table 2.6 shows the amounts of inter-provincial rice transferred through BULOG in Indonesia as of 2009 and 2010. South Sulawesi and East Java are the two dominant suppliers, representing around 80% together of the total amount of rice supplied to other provinces. On the other hand, Irian Jaya, NTT and North Sumatra are the three largest recipients of rice, jointly accounting for about a half of the total amount of rice received. While similar data on rice transfer through the private channel is not available for the present study, Table 2.6 gives an indication of the directions of inter-provincial rice flow. Table 2.7 shows the estimated level of rice self-sufficiency in the above-mentioned five provinces as well as at the national level. It indicates that, even if self-sufficiency of rice may be achieved at the national level, some provinces, such as NTT, still have a deficit, relying upon others for supply. The negative numbers in the rice surplus/deficit column for NTT and Irian Jaya may arise from errors in the assumptions as described in the notes of Table 2.7. These deficits, if any, may be covered by private distribution, which is not taken account of in the table. A striking contrast exists, as shown in Table 2.8, between provinces in terms of rice productivity as well as indicators concerning access to food, such as the numbers of the population below the poverty line and households without access to electricity.

Table 2.6 Rice transfers between provinces through BULOG in 2009 (upper) and 2010 (lower) (original data from BULOG, 2011)

		Rice amount received (thousand tons)							
		East Java	South Sulawesi	North Sumatra	NTT	Irian Jaya	Other provinces	Total	Share (%)
Rice amount supplied (thousand tons)	East Java	-	0	196	135	30	209	570	49.5
		-	0	116	0	56	150	322	38.5
	South Sulawesi	0	-	0	0	175	186	361	31.4
		0	-	0	56	107	168	331	39.6
	North Sumatra	0	0	-	0	0	32	32	2.8
		0	0	-	0	0	12	12	1.4
	NTT	0	0	0	-	0	0	0	0
		0	0	0	-	0	0	0	0
	Irian Jaya	0	0	0	0	-	0	0	0
		0	0	0	0	-	0	0	0
	Other provinces	0	0	40	37	0	111	188	16.3
		0	0	0	70	0	101	171	20.5
	Total	0	0	236	172	205	538	1,151	100
		0	0	116	126	163	431	836	100
	Share (%)	0	0	20.5	15.0	17.8	46.7	100	
		0	0	13.9	15.1	19.5	51.5	100	

Table 2.7 Rice production and consumption by province in 2010 (thousand tons unless otherwise stated) (original data from BPS, 2011; BULOG, 2011)

Province	Population (thousand persons)	Paddy production	Adjusted paddy production	Milled rice available for consumption	Rice consumption	Rice transfer through BULOG (net)	Rice surplus/ deficit
East Java	37,476	11,243	9,332	4,870	4,196	-322	352
South Sulawesi	8,033	4,501	3,735	1,949	899	-331	719
North Sumatra	12,985	3,515	2,917	1,523	1,454	104	173
NTT	4,679	567	471	246	524	126	-152
Irian Jaya	2,852	104	87	45	319	163	-111
Other provinces	171,531	48,221	40,023	20,887	19,205	260	1,942
Indonesia	237,556	68,151	56,565	29,520	26,597	0	2,923

Notes:

1) Paddy production figures were adjusted downward from BPS data by 17% to be conservative. This adjustment ratio was adopted from Rosner and McCulloch (2008).
2) The official conversion rates from wet paddy to dry un-husked paddy (86.02%), and from dry un-husked paddy to rice (62.74%), were used to calculate the amount of milled rice available for consumption. The paddy production figures were all assumed to be those of wet paddy for the present analysis.
3) The national average of rice consumption, 7,427 kg/capita/month in 2010 (BPS, 2011), was used uniformly to calculate the rice consumption within households in each province.
4) The share of rice consumption within households is uniformly assumed to be 79.6% of the total provincial rice consumption. This ratio was adopted from Rosner and McCulloch (2008).
5) Net rice transfer through BULOG was derived from Table 2.6.

Table 2.8 Paddy productivity and economic welfare by province (BPS, 2011; WFP, 2009)

Province	Paddy production per capita (thousand tons, 2010)	Paddy productivity (kg/ha, 2010)	Population below the national poverty line (%, 2007) (*)	Households without access to electricity (%, 2007)
East Java	300	6,046	9.07	2.89
South Sulawesi	560	5,088	21.33	12.32
North Sumatra	271	4,746	13.90	9.04
NTT	121	3,104	27.51	61.32
Irian Jaya	37	3,835	39.31	53.63
Indonesia	287	5,062	16.58	8.53

Note: (*) The national poverty line is defined as US$1.55 per person per day.

2.5. Climate variability, change and their impacts in Indonesia

2.5.1. Climate and its variations in Indonesia

Indonesia consists of more than 17,000 islands and lies on both sides of the equator. It is located between the Pacific and Indian Oceans, and between the Asian and Australian continents. The climate diversity in Indonesia, especially rainfall, is influenced by climate factors with different spatial and temporal scales. Rainfall is deemed to be the most important climate element in Indonesia. As this is an equatorial tropical region, the annual variation of surface temperature is not so significant. In contrast to the surface temperature, the rainfall is varied in spatial and temporal terms.

In terms of intra-annual rainfall patterns, Indonesia is divided into three climate regions with their distinct characteristics, as illustrated in Fig. 2.7 (Aldrian and Susanto, 2003). Region A is located in the southern part of Indonesia, including Java and Bali. Region B is located in northwest Indonesia from northern Sumatra to northwestern Kalimantan. Region C encompasses Maluku and northern Sulawesi. As Aldrian and Susanto (2003) describe, Region B has two peaks of seasonal rainfall, one from October to November and the other from March to May. Those two peaks are associated with the southward and northward movement of the inter-tropical convergence zone (ITCZ), a zone of low-pressure near the equator. This is in contrast with Region A, which has one peak from November to March and one trough from May to September, with a strong influence of monsoons. Region C has one peak from June to July and one trough from November to February.

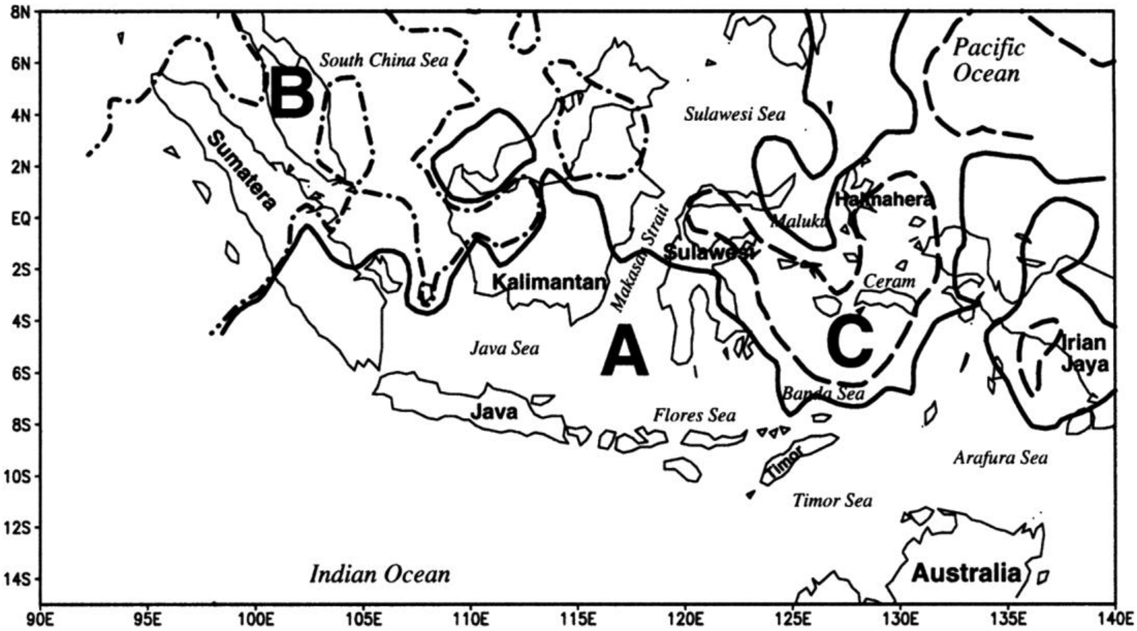

Fig. 2.7 Three climate regions in Indonesia: Region A in solid line, Region B in short dashed line and Region C in long dashed line (cited from Adrian and Susanto, 2003)

There are phenomena relating to meteorological disturbances that affect the nature of seasonal rainfall, known as the intra-seasonal variation, which lead to seasonal irregularities. This is also considered as a trigger for the occurrence of extreme weather events. Wheeler (2003) stated that the anomaly of rainfall in January 2002, triggering floods in various locations, was caused by the Madden-Julian Oscillation (MJO), which is an eastward movement of convection from the Indian Ocean to the Pacific Ocean at a speed of around 5-10 m/s and a duration of around 30-60 days (Hendon and Salby, 1993; Zhang, 2005; Tangang *et al*., 2008; Duncan and Han, 2009; Salahuddin and Curtis, 2009; Webber *et al.*, 2010). On the other hand, Wu *et al*. (2007) and Trilaksono *et al*. (2011) attributed the large flood in Jakarta in 2007 to the cold surge, which is a flow of cold air mass from the Eurasian lands accompanied by a decline in temperature in most of the South East Asian region. Conversely, the southerly surge strengthens the wind going northward and shifts the position of ITCZ to the north, causing a decline of rainfall over Java and Nusa Tenggara (Davidson, 1984). The interaction among the phenomena relating to the intra-seasonal variation, such as those described above, makes the climate pattern in the Indonesia-Australia region complex.

As for inter-annual climate variations, the El Nino-Southern Oscillation (ENSO) and the Indian Ocean dipole (IOD) are two dominant modes in the tropical Pacific and Indian Oceans respectively, with a strong influence on the climate of Indonesia. There are two modes of ENSO, El Nino and La Nina. When El Nino is in effect, drier conditions prevail over Indonesia (Sahu *et al.*, 2010). El Nino, which lasts from June to November, reduces an already low rainfall in Region A and thus causes drought. While Regions A and C have a strong ENSO influence, Region B has little relevance to the ENSO impact (Aldrian and Susanto, 2003). IOD is a coupled ocean-atmospheric phenomenon in the tropical Indian Ocean. Recent studies (Saji *et al.*, 1999; Behera and Yamagata, 2003) found that IOD also has a strong influence on the climate of Indonesia. Like ENSO, there are two modes of IOD events, a positive and a negative IOD. A positive IOD causes drier conditions in Indonesia, particularly in the western part of the country. An IOD event usually starts around May or June, peaks between August and October, and then rapidly decays (Sahu *et al.*, 2010).

The maritime climate in Indonesia is also affected by the Asia-Australia monsoon circulation through the subsequent change in sea flow and vertical movements of sea waters (BAPPENAS, 2012). Generally, the sea surface temperature (SST) is above 28^{o}C in January and below 27^{o}C in August. The decline in SST is mainly due to upwelling of waters in the Indian Ocean as a result of the easterly wind in the Australian cold monsoon season, which causes migration of colder sea water mass from the Indian Ocean to the Java Sea. Conversely, the westerly wind brings in warmer sea waters from the Pacific Ocean around January. The sea flows associated with the monsoon circulation also affect sea level. Generally, it rises in January and falls in August. The inter-annual climate variations, such as ENSO and IOD, also influence it. Sofian (2007), for example, states that the increase in sea level is caused by La Nina, which strengthens trade winds in the Pacific Ocean, thereby bringing a water mass from the East Pacific around Peru to Indonesia. The sea level also rises in association with tropical storms and other weather disturbances. A tropical storm that occurs near the coastline can result in a rise of the sea surface, which is known as a storm surge.

2.5.2. Observed and projected climate change

According to the latest National Communication of Indonesia (Ministry of Environment, 2010), a significant increase in maximum and minimum temperatures was observed from 1980 to 2002 in most of the stations in the country. On average, the rate of changes in minimum and maximum temperatures across 33 stations was 0.047 ^{o}C and 0.017 ^{o}C per year respectively. In ocean waters surrounding Indonesia, in the period 1993-2008, the average rate of SST increase ranged from 0.020 °C/year to 0.023 °C/year. The increase in global temperature caused an increase in sea level rise. Based on analysis of altimeter data from January 1993 to December 2008, it was found that the rate of sea level rise ranged from 0.2 cm/year to 1 cm/year, with an average of approximately 0.6 cm/year.

According to the Ministry of Environment (2010), the trend analysis of historical rainfall data from 384 stations over time scales between 20 and 50 years indicates a significant decrease in

December-January rainfall over a large portion of Kalimantan, whereas a substantial increasing trend has been observed in most of Java and eastern Indonesia, including Bali and Nusa Tenggara. For June-August rainfall, a significantly decreasing trend was observed in most of the Indonesian region with some exceptions. The monsoon onset also changed in many parts of Indonesia. Based on analysis of data from 92 stations, the monsoon onset has been increasingly delayed in some parts of Indonesia, particularly in Java. Similarly, the length of wet seasons has tended to shorten, particularly in Java and Kalimantan.

Ministry of Environment (2010) also made assessment of the simulations on 14 general circulation models (GCMs) under different emission scenarios. Most of the models agree that the seasonal rainfall from December to February will increase in Java by 2025, while the rainfall from June to August in most parts of Java is likely to decrease. The impact of global warming on the monsoon onset in Java and Bali was studied by Naylor *et al*. (2007), using more GCMs and empirical downscaling models. It was found that the onset of rainy season in Java and Bali is projected to delay under a changing climate. Emanuel (2005) also suggested that increasing SST will strengthen tropical cyclones, causing strong winds and heavy rainfalls.

2.5.3. Climate impacts on rice production and distribution

A number of studies have been conducted to evaluate the impact of climate variability and change on rice production in Indonesia. Amien *et al*. (1996, 1999) and Matthew *et al*. (2007) used climate scenarios as inputs to rice crop models to project the effect of changes in temperature, rainfall and CO_2 concentration on rice yield in Java. They found the models to predict a future yield reduction under climate change. Similarly, Keil *et al*. (2009) projected the impact of rainfall change on rice yield in Central Sulawesi. Their model simulations also showed that El Nino-related drought leads to drastic declines of crop yields and hence, agricultural incomes. Falcon *et al*. (2004) found that the rice production anomaly in Java and Sulawesi could be correlated well with the anomaly of SST in August over the Pacific Ocean. Naylor *et al*. (2007), on the other hand, revealed a marked increase in the probability of a 30-day delay in monsoon onset in 2050, underlining a need for adaptation strategies in rice production, including investments in water storage, drought-tolerant crops, crop diversification, and early warning systems. Little has been examined, however, about climate impacts on rice distribution, even though food availability relies upon not only production but also distribution channels to get food where it needs to be. The climate impacts on rice production and distribution are summarized in Table 2.9.

Table 2.9 Potential climate impacts on rice production and distribution in Indonesia (with reference to BAPPENAS, 2012)

Climate indicators	Potential climate hazards	Relevance to rice production (P) and distribution (D) (P)	(D)
Surface temperature	Increased evapotranspiration leading to droughts	x	
	Change in pattern of migration of plant diseases	x	
Rainfall	Droughts caused by a deficit in total precipitation	x	
	Floods due to increases in total amount, duration and intensity of rainfall	x	x
	Landslides	x	x
	Increased temperature and changing rainfall pattern, leading to declines in agricultural production	x	
Sea level	Sea water inundation in coastal areas	x	x
	Sea water intrusion through ground water and rivers	x	
Extremes relating to ENSO/IOD	Consecutive drought years	x	
	Change in seasonal rainfall pattern	x	
	Increase in heavy rains, strong winds and waves	x	x
Frequency and intensity of extreme climate	Frequent and intense rains, storms, winds and waves	x	x
	Increased floods and erosion	x	x

2.6. Policy responses in Indonesia

At the time of this writing, the National Action Plan for Climate Change Adaptation (*Rencana Aksi Nasional untuk Adaptasi Perubahan Iklim*, RAN-API) is being finalized. RAN-API is aimed to provide the directions for mainstreaming climate change adaptation into national, local and sectoral development planning. It consists of actions directed towards strengthening the resilience of (1) the economic system, (2) livelihood, (3) environmental services and (4) special areas, such as coastal areas and small islands. It also includes strengthening a common capacity to support enhancing the above resilience. RAN-API has five major categories, each of which has its sub-categories, such as food security under the economic resilience. Each sub-category consists of several clusters, which in turn contain more detailed action plans, along with information on the scope of actions, priority locations and institutions involved for each. The structure of RAN-API is summarized in Table 2.10, where those sub-categories and clusters relating to rice production and distribution are so marked respectively.

Coordination is one of the main challenges as ministries and agencies at different levels are involved in the planning and implementation of RAN-API. In regard to this, the Government of Indonesia has established the Climate Change Coordination Team under the Ministerial Decree of the National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional*, BAPPENAS). The Team consists of the steering committee and six working groups: (1) agriculture, (2) forestry and peat land, (3) energy, transportation and industry, (4) waste, (5) cross-sector and (6) adaptation. The working group on adaptation has tasks, among others, (1) to coordinate the implementation of programs and activities in adaptation, (2) to synchronize the work plans of relevant line ministries, and (3) to formulate biannual and annual progress reports (BAPPENAS, 2012).

While the RAN-API covers all the relevant sectors, there are also adaptation policies specific to the agricultural sector. Two most recent legal documents are introduced below because of their significance and relevance to the subject of this thesis. One is the Presidential Instruction 5/2011, enacted in March 2011, concerning national security of rice in anticipation of extreme climate events. Another is the Law concerning Protection and Empowerment of Farmers, which was passed in the House of Representatives in July 2013.

The Presidential Instruction 5/2011 (Cabinet Secretariat of the Republic of Indonesia, 2011) is aimed to increase resilience of rice production and distribution to be better able to respond to extreme climate events. It is directed at the relevant ministries, agencies and local governments to take necessary measures under their respective responsibilities to ensure rice availability across the country in anticipation of unusual climate events. The relevant entities include, among others, MoA mainly concerning provision of inputs and other supports to rice farmers, PU on development of infrastructure for irrigation, the Ministry of Transportation on infrastructure for distributing rice and production inputs, such as fertilizers, the Ministry of Trade for its supervisory role over BULOG on rice distribution and reserve, BMKG on provision of climate information, the Ministry of Finance on securing national budget, and BAPPENAS on monitoring and evaluation of the implementation of this Presidential Instruction. Some of the instructions are listed in Table 2.11, where their relevance to rice production and distribution is also indicated.

Table 2.10 Summary of RAN-API (with reference to BAPPENAS, 2012)

RAN-API / action plans relating to rice production and distribution	Relevance to rice production (P) and distribution (D)	
	(P)	(D)
Economic resilience		
Food security		
Adjustment of food production system (e.g., introduction of new varieties, planting patterns and cultivation technologies)	x	
Expansion of food cropping area	x	
Restoration and development of agricultural infrastructure (e.g., irrigation)	x	x
Acceleration of food diversification		
Development of adaptive technology (e.g., R&D for pest-resistant and higher-yield varieties)	x	
Improvement of climate communication (e.g., crop calendar)	x	x
Energy security		
Livelihood resilience		
Health		
Settlements		
Infrastructure		
R&D for enhancing resilience of infrastructure	x	x
Improvement of access to roads and bridges	x	x
Resilience of environmental services		
Ecosystems and biodiversity		
Rehabilitation of degraded ecosystems (e.g., improvement of river basin management)	x	
Resilience of special areas		
Urban areas		x
Coastal areas and small islands	x	x
Support system		
Enhancement of capacity of stakeholders for adaptation to climate change	x	x
Improvement of climate information system	x	x
Research and science for climate change adaptation	x	x
Improvement of planning and budgeting	x	x
Monitoring and evaluation of the progress of adaptation	x	x

Table 2.11 Summary of the Presidential Instruction 5/2011 (with reference to the Cabinet Secretariat of the Republic of Indonesia, 2011)

Ministries/agencies concerned and their responsible actions under the Presidential Instruction 5/2011	Relevance to rice production (P) and distribution (D)	
	(P)	(D)
Ministry of Agriculture (MoA)		
To conduct impact risk analysis of extreme climate events on rice production	x	
To enlarge cropland size and strengthen irrigated water management	x	
To increase availability of seeds and fertilizers	x	
To enhance farming practices including coping with floods and droughts	x	
To strengthen extension services to farmers	x	
To improve post-harvest activities to reduce product loss	x	
Ministry of Public Works (PU)		
To strengthen irrigation infrastructure development	x	
Ministry of Transportation		
To develop transportation infrastructure for distribution of rice and production inputs	x	x
Bureau of Logistics (BULOG) under the Ministry of Trade		
To strengthen rice distribution from surplus to deficit areas		x
To strengthen managing rice reserve		x
Ministry of Finance		
To allocate the national budget for the implementation of this Instruction	x	x
Ministry of Home Affairs		
To carry out guidance and supervision for local governments	x	x
Agency for Meteorology, Climatology and Geophysics (BMKG)		
To conduct analysis of extreme climate conditions, and disseminate early warning information to the MoA and other relevant ministries/agencies	x	x
Local governments		
To implement anticipatory responses in their respective jurisdictions	x	x
To allocate local budgets for the implementation of this Instruction	x	x
Ministry of National Development Planning (BAPPENAS)		
To coordinate the formulation of mid-term policy concerning adaptation	x	x
To conduct monitoring and evaluation of the implementation of this Instruction	x	x

The Law concerning Protection and Empowerment of Farmers (Cabinet Secretariat of the Republic of Indonesia, 2013) is aimed to improve the welfare of farmers in Indonesia (Article 4), where the protection of farmers is referred to as the effort to assist them in dealing with problems of climate change among others (Article 1). The protection is implemented through development of agricultural infrastructure and facilities, provision of business certainty, introduction of agricultural insurance and so forth (Article 7). The agricultural infrastructure as intended in the Law includes farm roads, reservoirs and irrigation networks, and warehouses among others (Article 16), while the agricultural facilities are intended to include seeds and fertilizers (Article 19). Government support for provision of these agricultural infrastructure and facilities is stipulated in Articles 17 and 21. Business certainty is intended to include securing cropland through government regulations (Article 22). The Law also stipulates government support for provision of agricultural insurance, which is intended to protect farmers from losses due to natural disasters, pests, diseases and impacts of climate change (Article 37). It is stipulated that the government will facilitate farmers' participation in insurance by assisting premium payment and other measures, while the details of the implementation will be provided by the ministerial regulation (Article 39). Implementation of the stipulated measures is subject to monitoring, reporting and evaluation (Article 92).

The discussions in this chapter are summarized in Fig. 2.8. Climate impacts exacerbate existing socio-economic problems, making it even more difficult to achieve food security. Many of the response measures are intended to improve the socio-economic environment for rice production and distribution, thereby making it more resilient to climate impacts. As new findings emerge on climate impacts and their interactions with socio-economic problems, the government will need to reassess and redesign their response measures.

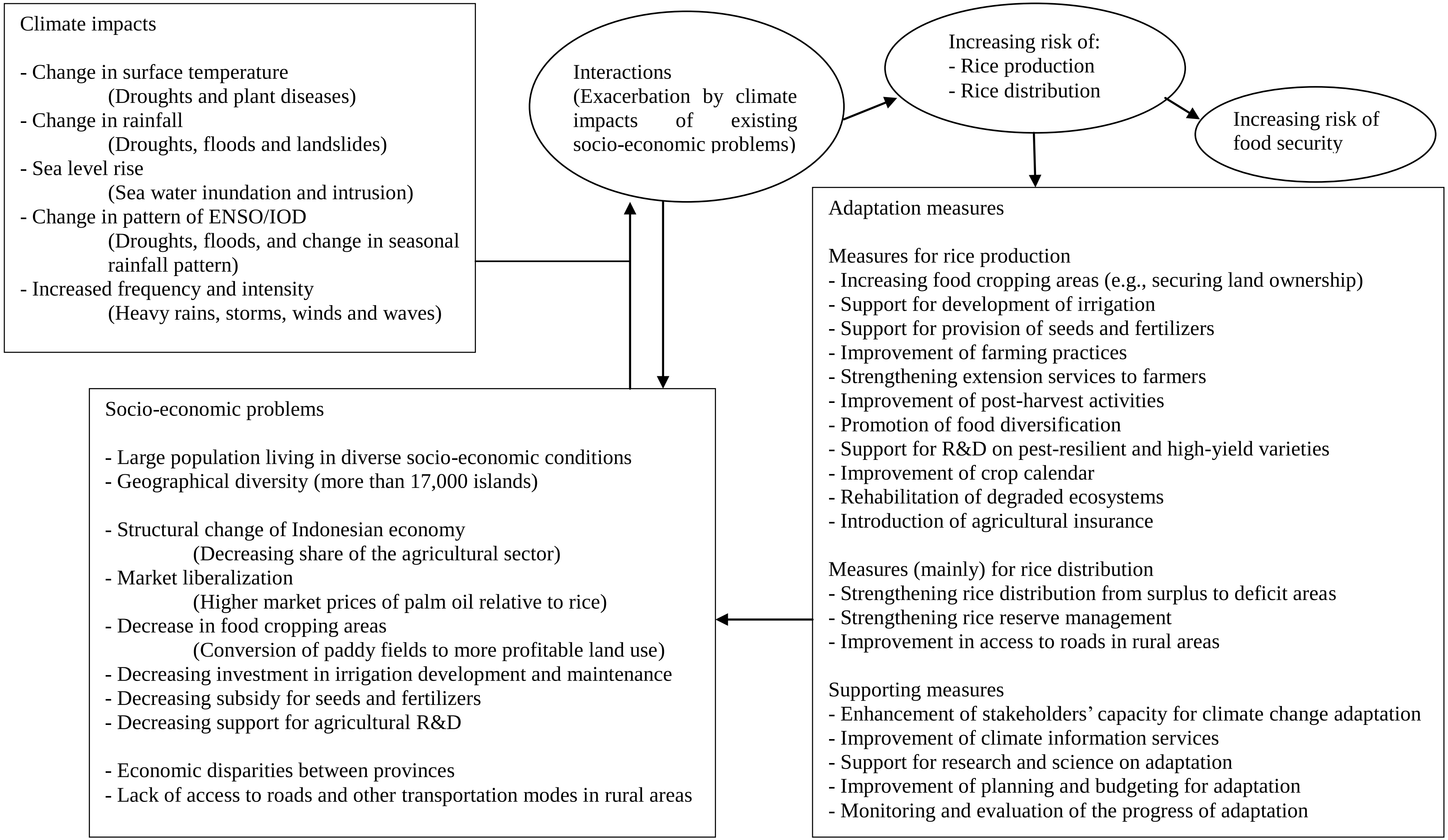

Fig. 2.8 Exacerbation by climate impacts of socio-economic problems on rice production and distribution, and adaption measures in Indonesia (produced by the author)

3. Response of Rice Farmers to Climate and Socio-economic Impacts: A Case Study in North Sumatra

3.1. Introduction

Securing an adequate and stable supply of rice for the increasing population is a major issue for Indonesia. There are increasing concerns, however, in relation to environmental factors, such as climate change; and socio-economic changes, such as competition for land use with oil palm and other cash crops. A number of studies have been conducted to evaluate the impact of climate variability and change on rice production in Indonesia. Amien *et al*. (1996, 1999) and Matthew *et al*. (2007) used climate scenarios as inputs to rice crop models to project the effect of changes in temperature, rainfall and CO_2 concentration on rice yield in Java. They found the models to predict a future yield reduction under climate change. Similarly, Keil *et al*. (2009) projected the impact of rainfall change on rice yield in Central Sulawesi. Their model simulations also showed that El Nino-related drought leads to drastic declines of crop yields and hence, agricultural incomes. Falcon *et al*. (2004) found that the rice production anomaly in Java and Sulawesi could be correlated well with the anomaly of SST in August over the Pacific Ocean. Naylor *et al*. (2007), on the other hand, revealed a marked increase in the probability of a 30-day delay in monsoon onset in 2050, underlining a need for adaptation strategies in rice production, including investments in water storage, drought-tolerant crops, crop diversification, and early warning systems.

While rice production is influenced by both natural and socio-economic factors, comprehensive studies on these impacts have been limited. In addition, the geographical focus of existing studies on Indonesia has been restricted to Java and to a lesser extent Sulawesi. Against this backdrop, the objectives of this chapter are threefold. Firstly, it aims to understand the recent change in rice production and land use. Secondly, it will examine the combination of climate and socio-economic factors that have contributed to the change in rice production, in particular land use conversion from rice production to oil palm plantation. Thirdly, it will identify types of farmers' responses, and the variables that differentiate them. This study will then consider the questions of whether climate change will exacerbate those problems, and what adaptation actions will be required.

The province of North Sumatra is selected as the target area of this study for the following two reasons. Firstly, the province is a significant producer of both rice and palm oil, where competition for land use is fierce. As Table 1.1 in Chapter 1 shows, while it is the second largest rice-producing province outside the Island of Java after South Sulawesi, it is also the second largest palm oil producing area in Indonesia after Riau, another province in the Island of Sumatra. Secondly, as indicated by the Ministry of Environment (2010) and Kitoh *et al*. (2010), the province is facing observed and projected climate change. Thus, North Sumatra is a typical area which is suitable for studying whether and how climate and non-climate factors affect rice production land use.

The present study evaluates climate and non-climate impacts on rice production at regency as well as provincial levels. Four regencies - Labuhan Batu, Tapanuli Selatan, Simalungun and Langkat - are selected, as they are among the largest rice harvest areas in the province as of 2006 (Agriculture Office of North Sumatra, 2010). The regencies have different geographical conditions: Labuhan Batu is in the eastern coastal area, Tapanuli Selatan is in the highlands south of Lake Toba, Simalungun is on the hillside north of a lake, and Langkat is in the northern coastal area. Because of the ongoing decentralization process, each of the four regencies is being separated into even smaller jurisdictions.

Note: This chapter has been published as Kawanishi and Mimura (2013a).

3.2. Changes in rice production and land use in North Sumatra

3.2.1. Overview of North Sumatra

North Sumatra (Fig. 3.1) is one of 33 provinces in Indonesia. It is located at latitude 1°-4°N and longitude 98°-100°E with a land area of over 70 thousand km^2. It faces the Indian Ocean on the west and the Malacca Strait on the east. Lake Toba, the largest freshwater lake in Indonesia, lies in the middle of the province. Its topography is varied: lowlands in the east, highlands in the center, and undulating plains in the west. Subsequently, there is a variation of local climate. Administratively, the province consists of 25 regencies and 8 cities (*kota*) (BPS North Sumatra, 2010).

According to the Agriculture Office of North Sumatra (2011), the agricultural sector accounts for 23% of the regional GDP and employs 47% of the total workforce. Rice is important not only as the staple food, but also for the sake of employment, rural livelihood and poverty reduction in the province. The peak planting season is from November to December, and harvesting peaks from February to March. While there is another harvest season from August to September, it is not as significant as February/March in terms of harvest volume.

As Aldrian and Susanto (2003) indicate, in terms of intra-annual rainfall pattern, North Sumatra follows the equatorial pattern marked with two peaks in a year: one from October to November, and the other from March to May. These two peaks are associated with the southward and northward movement of the ITCZ, a low-pressure zone near the equator. This pattern is also observed in the average monthly rainfall from 1997 to 2010 in Medan, the provincial capital of North Sumatra, as shown in Fig. 3.2.

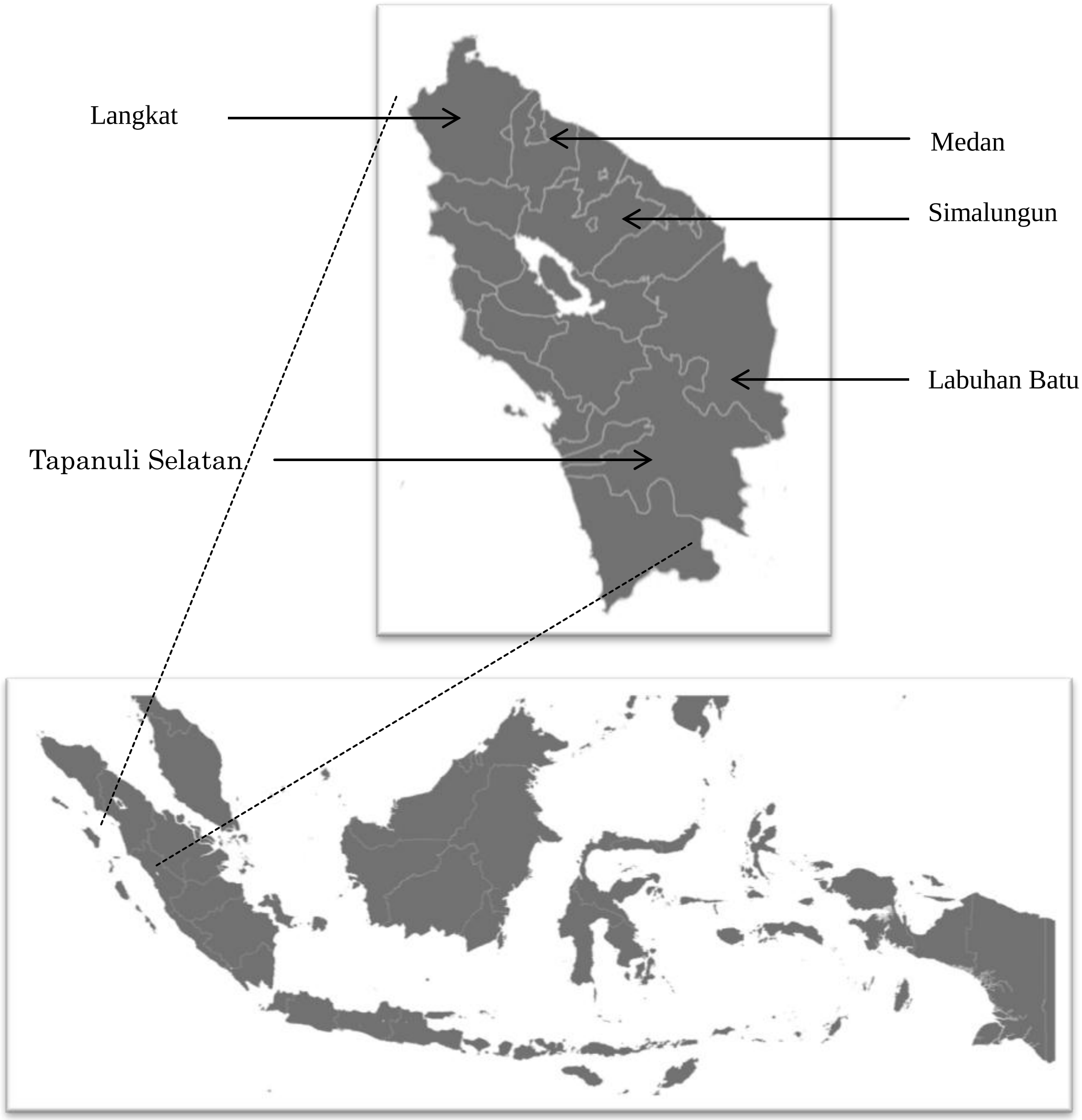

Fig. 3.1 Map of North Sumatra (drawn on the map from BPS North Sumatra, 2010)

With regards to inter-annual climate variations, the geographical location of North Sumatra makes it prone to the impacts of IOD, with little relevance to ENSO (Aldrian and Susanto, 2003). An IOD is a coupled ocean-atmospheric phenomenon in the tropical Indian Ocean. Like El Nino and La Nina of the ENSO, there are two modes of IOD events. A positive IOD causes drier conditions, while a negative IOD results in an increase of rainfall in the western part of Indonesia (Saji *et al.*, 1999; Behera and Yamagata, 2003).

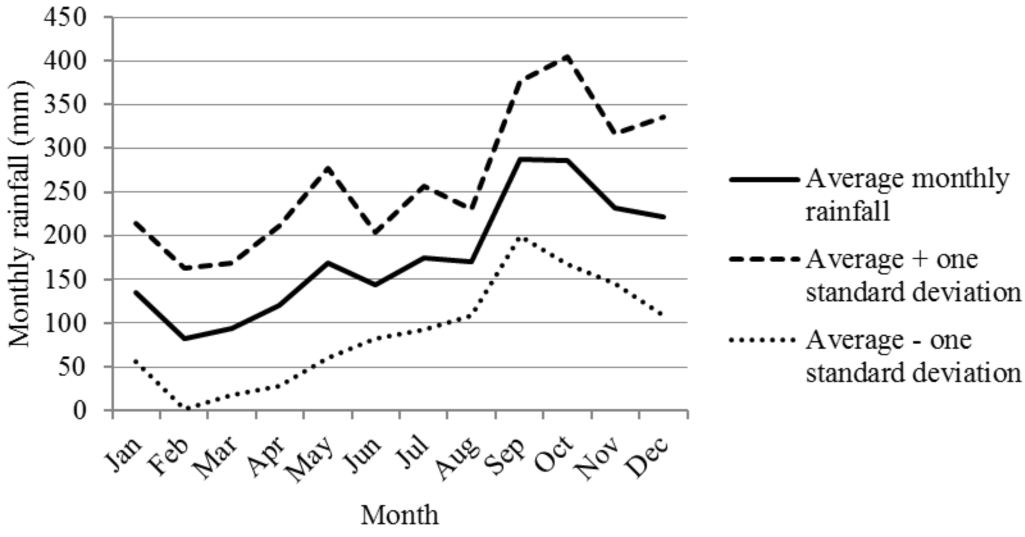

Fig. 3.2 Average monthly rainfall in Medan (original data from BPS North Sumatra, 1998-2011)

3.2.2. Changes in rice production

In 2009, the provincial governor of North Sumatra issued a regulation on the ‘Food Self-Sufficiency Program’ for the period until 2025 (Governor Regulation No. 25/2009). In order to achieve self-reliance of food in the province, the regulation set targets on rice production, productivity and harvest area to be achieved by 2015 and 2025. As presented in Table 3.1, the latest status of rice production is far below the target set by the regulation for the year 2015. Even though the actual figure for rice productivity in 2009 had already surpassed the target, the latest status of rice harvest area is less than the target by 14%. Behind the issue regarding the Governor Regulation, there was a historical change in the environment surrounding rice production.

Table 3.1 Rice production in North Sumatra: Actual data and policy targets (BPS North Sumatra, 2010; Governor’s Office of North Sumatra Province, 2009)

	2009 (actual)	2015 (target)	2025 (target)
Rice harvest area (ha)	768,407	893,646	1,006,835
Rice productivity (kg/ha)	4,591	4,570	5,185
Rice production (ton)	3,527,899	4,084,264	5,220,099

To extract the features of the change, a time series analysis of land use for rice production and oil palm plantation was performed at both provincial and regency levels, using data from BPS and the Agriculture Office of North Sumatra. Figure 3.3 illustrates the trends in rice production, rice productivity and rice harvest area from 2000 to 2009 in North Sumatra. There are some characteristics identified in these trends. Firstly, rice production has achieved almost no growth over the last decade. The production figures in 2000 and 2009 are both around 3.5 million tons. Secondly, rice productivity improved by more than 10% from 4.1 thousand kg/ha in 2000 to 4.6 thousand kg/ha in 2009. Thirdly, rice harvest area, in contrast, was reduced by more than 9% from 848 thousand hectare in 2000 to 768 thousand hectare in 2009. The decrease in rice harvest area has essentially offset the improvement in rice productivity during the period. Fourthly, major reductions in rice harvest area were observed in 2002 and 2006. The decrease was more marked in 2006. The harvest area decreased by more than 14% from 822 thousand hectare in 2005 to 705 thousand hectare in 2006. Accordingly, rice production was reduced by around 13% in the year. The relationship between rice production and annual rainfall seems complicated, because a significant decrease in rice production occurred in 2002 and 2006, although 2002 had the smallest rainfall while 2006 had the largest during this period. The relationship between rice production and rainfall will be discussed later.

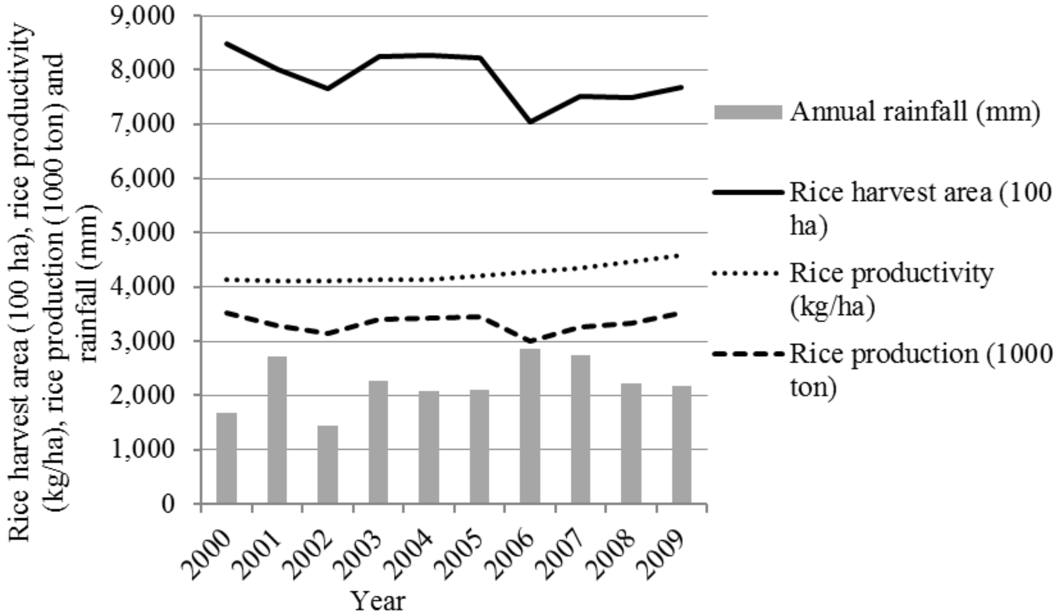

Fig. 3.3 Rice production, rice productivity, and rice harvest area in North Sumatra, along with annual rainfall monitored at Sampali Station in Medan (BPS North Sumatra, 2001-2010)

3.2.3. Land use conversion from rice to oil palm

Figure 3.4 summarizes the annual trends in the areas of smallholdings for oil palm, enterprise estates for oil palm and smallholdings for rubber. In contrast to rice production, oil palm plantation area has been expanding in the province, most significantly from 2004 to 2008. While enterprise estates remained almost at the same level, smallholder estates more than doubled over the last decade, with an increase of 237 thousand hectare. During the same period, the rice-planted area decreased by about 135 thousand hectare (BPS North Sumatra, 2001-2010). The increase in oil palm smallholdings is also significant in comparison with the modest growth of those producing rubber during this period. Interviews with government officials and farmers, as well as focus group meetings, as recorded in BAPPEDA North Sumatra (2011), indicate that the sharp drop in rice harvest area is mainly due to land use conversion from rice production to oil palm plantation, and this is supported by the trend data above. Site visits also find a number of cases where recently created patches of oil palm plantation lie side by side with paddy fields.

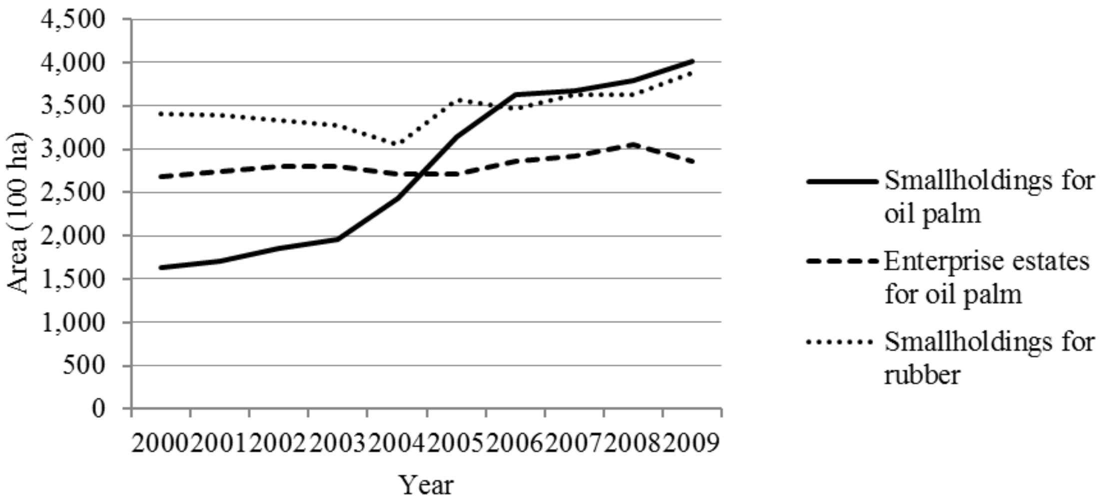

Fig. 3.4 Areas of smallholdings for oil palm, enterprise estates for oil palm, and smallholdings for rubber in North Sumatra (BPS North Sumatra, 2001-2010)

The conversion to oil palm plantation does not occur only from paddy fields but may also be due to conversion from forests, as discussed by Wich *et al*. (2011). They estimated the total forest loss at 43.4% from 1985 to 2007 in North Sumatra, and attributed the loss to road construction, agricultural expansion, logging and mining. Within this agricultural expansion, they identified large-scale oil palm plantation as the most visible threat. As Fig. 3.4 indicates, however, there has been no substantial growth in the area of palm oil enterprise estates in recent years. This suggests that the recent forest loss is not due to large-scale oil palm plantation, while small-scale encroachment for oil palm plantation may be a cause.

Thus, the reduction in rice harvest area has offset the consistent increase in rice productivity, resulting in almost no growth in rice production over the last decade in North Sumatra. In contrast, oil palm plantations, particularly smallholder estates, have been expanding in the province. Factors affecting these changes in land use will be examined in the following section.

3.3. Factors affecting land use conversion

There is limited statistical data available on the causes for land use change in North Sumatra. To overcome the limitation, interviews with government officials and farmers, as well as focused group meetings with relevant agencies, were conducted. The government agencies that were interviewed included the Agricultural Office, BMKG, PU, BULOG and the Food Security Agency as well as the BAPPEDA North Sumatra. The interviews with farmers took place at several locations in Simalungun and its neighboring regencies. The minutes of meetings were recorded in BAPPEDA North Sumatra (2011). At first, focus group meetings at the provincial government were conducted to obtain an understanding on the recent changes in land use and list their potential causes. These included climate conditions; economic environment, such as price differences between rice and oil palm; a rice planting index associated with access to water; distance from mills at palm oil enterprise estates; lack of enforcement of land use regulations; and lack of policy coordination. Semi-structured interviews with government official and farmers were then conducted on a list of questions to ask them to cite the causes which they consider as most relevant. Through these surveys, four factors were extracted as relevant for affecting rice production and land use: (1) climate conditions, (2) economic environment, (3) a rice planting index, and (4) distance from palm oil enterprise estates. They were further validated with literature and other sources of evidence, which included statistical data collected from BPS, BMKG, and the Agriculture Office of North Sumatra. Archival records and newspaper articles were also taken as supplementary materials.

These sets of data were utilized for time series analyses from 2000 to 2009 for rice production and land use conversion from rice to oil palm; time series analyses of annual rainfall from 1991 to 2010 and monthly rainfall from 1997 to 2010 in Medan; their comparison with rice harvest area in the province from 2000 to 2010; a time series analysis of monthly farmers' net terms of trade by crop type from 2008 to 2010; and a time series analysis of oil palm plantation area divided by rice harvest area at the regency level from 2001 to 2010.

3.3.1. Climate conditions

According to Pasaribu and Syukur (2010), the actual rice area affected by flood and drought was 333 thousand hectare and 319 thousand hectare in 2008 in Indonesia, with the production loss amounting to 997 thousand and 984 thousand tons respectively. The total production loss due to flood and drought was about 2 million tons, which is 3.7% of the national rice production of the year. This indicates that flood and drought equally adversely affect the rice harvest area and production in Indonesia. As comparable data at the provincial level is not available, this study examined the temporal trend in rainfall as a typical climatic parameter, and compared it with the trend in seasonal rice harvest area in North Sumatra. The climate impacts were assessed using a data set for the annual rainfall from 1991 to 2010, as well as the monthly rainfall from 1997 to 2010 monitored at Sampali Station in Medan (BPS North Sumatra, 1992-2011).

Figure 3.5 shows the change of annual rainfall from 1991 to 2010 in Medan (BPS North Sumatra, 1992-2011). The average annual rainfall during the period is 1,994 mm with a standard deviation of 459 mm. There are three years (1994, 1997 and 2002) when the annual rainfall was below 1,535 mm, which is the average minus one standard deviation. There are also three years (2001, 2006 and 2007) when it was over 2,453 mm, which is the average plus one standard deviation. An upward trend of 34.5 mm/year is observed for annual rainfall in Fig. 3.5. This agrees with the observed climate change as described in the latest National Communication of Indonesia (Ministry of Environment, 2010), which reports that the northern coastal area of Sumatra has been getting wetter in recent years. In terms of large-scale climate phenomenon, as compiled by Sahu *et al*. (2010) and Yulihastin *et al*. (2008), a positive IOD occurred in 1994 and 1997 as well as the three consecutive years from 2006 to 2008. A positive IOD co-occurred with El Nino in 1997 and 2006, and with La Nina in 2007.

Two observations can be made from the comparison between the trend in rainfall in Medan and the large-scale climate modes as described above. Firstly, anomalous rainfall was recorded in Medan in most of the years when a positive IOD occurred, and every year when it co-occurred with an ENSO. Secondly, despite this linkage, the local impacts of large-scale climate phenomena are varied. Most notably, there is a distinct contrast between 1997 and 2006. In both years, a positive IOD and El Nino co-occurred, resulting in unusually dry conditions in most parts of Indonesia. In Medan, however, while unusually dry conditions prevailed in 1997, the maximum annual rainfall over the last 20 years was recorded in 2006, as presented in Fig. 3.5 and Table 3.2. In this respect, Harijono (2007) argues that the general conclusion concerning the impacts of an IOD and El Nino needs to be interpreted cautiously for some regions including the northern part of Sumatra. Rao *et al.* (2009) attributed this to exacerbation of the northern portion of the ITCZ in IOD years, which stimulates a process of air-mass transportation and cloud formation over this area.

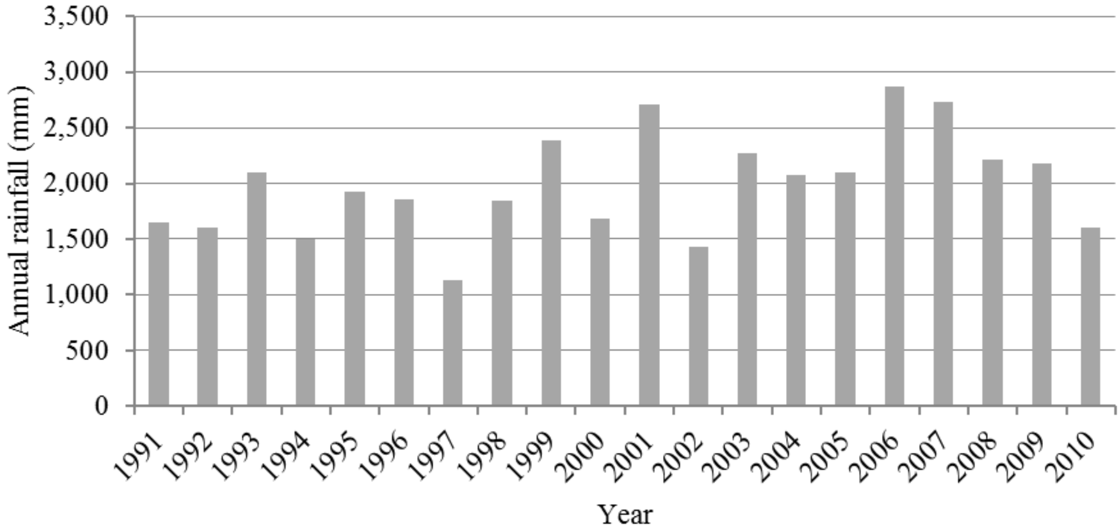

Fig. 3.5 Annual rainfall from 1991 to 2010 monitored at Sampali Station in Medan (BPS North Sumatra, 1992-2011)

Table 3.2 Annual rainfall from 1991 to 2010 and monthly rainfall from 1997 to 2010 at Sampali Station in Medan (original data from BPS North Sumatra, 1992-2011)

	Annual rainfall	Rainfall Nov.-Dec.	Rainfall Jan.-Feb.	Rainfall Apr.-May	Rainfall Jun.-Jul.
Average (mm)	1,994	453	217	289	318
Maximum (mm)	2,864	683	589	670	510
Minimum (mm)	1,137	225	95	75	147
Standard deviation (mm)	459	145	127	177	107
Measurement for 2002 (mm)	1,431	683*	95	164	147
Z-score for measurement in 2002	-1.23	1.60	-0.96	-0.71	-1.60
Measurement for 2006 (mm)	2,864	633*	369	670	376
Z-score for measurement in 2006	1.89	1.25	1.19	2.15	0.54

Note:
(*) The numbers are the measurements for rainfall from November to December in 2001 and 2005 respectively.

Figure 3.6 illustrates the trend in rice harvest area for two seasons, i.e., January to April and May to August over the last ten years. These are compared with rainfall during the corresponding planting months (November to December and April to May) and growing months (January to February and June to July). As seen in Fig. 3.6, there was high precipitation from November to December in 2001, and low precipitation during the following season of January to July in 2002. As summarized in Table 3.2, the rainfall from November to December in 2001, the planting season for the first harvest in 2002, was the highest for these months over the last 14 years, while two growing seasons in 2002, January to February and June to July, were the driest. The decrease in harvest areas in 2002 might have been caused by such unusual weather conditions. Similarly, as seen in Fig. 3.6, unusually heavy rainfall occurred during the planting times in 2006, when the harvest area decreased again. As presented in Table 3.2, the rainfall from November to December in 2005, the planting time for the first harvest in 2006, was very high, and the rainfall from April to May in 2006 was the highest for these months over the last 14 years. The z-score for the rainfall for these two months in 2006 is 2.15, indicating that the degree of anomaly in rainfall was particularly strong from April to May in 2006. These analyses suggest the possibility that unusual weather events triggered the reduction of rice harvest areas, events that in turn were caused by larger scale phenomena such as an IOD.

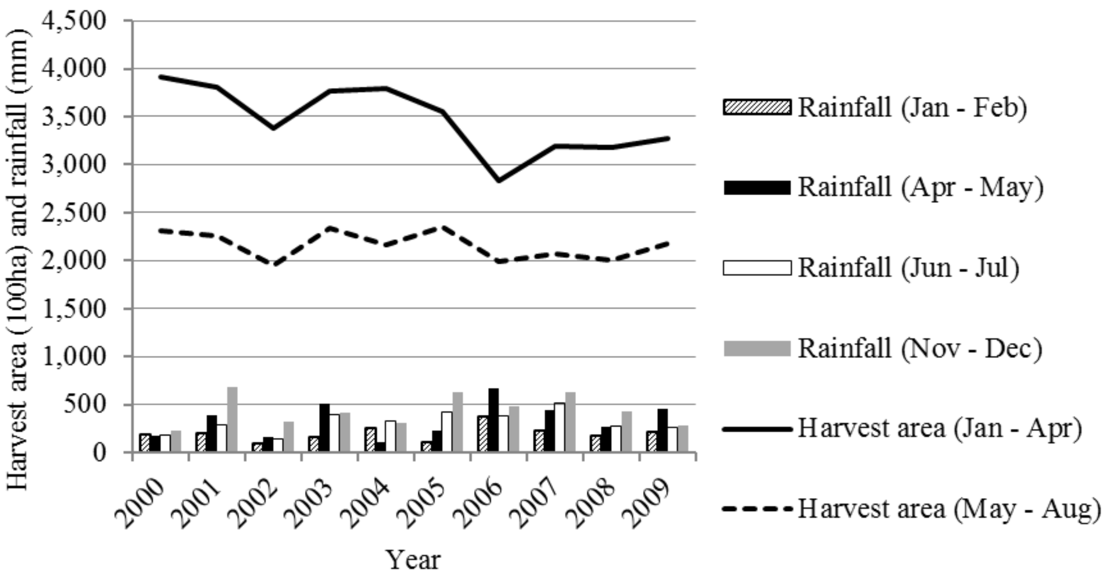

Fig. 3.6 Rice harvest area by season in North Sumatra (BPS North Sumatra, 2009a), along with rainfall amounts during planting and growing months as monitored at Sampali Station in Medan (BPS North Sumatra, 2001-2010)

Given the variation of local climates in North Sumatra, the climate anomaly should also be examined on a local basis. For this purpose, the monthly rainfall data from 2001 to 2009 was analyzed for the targeted four regencies, which was provided by the North Sumatra office of BMKG. However, the data set is insufficient because some of the monthly data is missing. For Tapanuli Selatan, the data is available only after 2004. With this limitation in mind, the rainfall in two planting times in 2006 for the four regencies is summarized in Table 3.3. The rainfall pattern in Labuhan Batu, Simalungun and Langkat is similar to that in Medan. The rainfall from April to May in 2006 was the highest for these months in the decade in Simalungun and Langkat, located in the northern part of the province. The precipitation from November to December in 2005 was also high in these regencies. Labuhan Batu, located in the eastern part of the province, was also very wet. Particularly, the rainfall in April 2006 was the highest for the month in this regency over the last decade. In contrast to these regencies, Tapanuli Selatan, located in the mountainous area to the southwest of the province, experienced unusually dry conditions, which started in December 2005 and continued until July in 2006. This suggests that rice production in Tapanuli Selatan was impacted by climate differently from the three other regencies, and this is because of its geographic conditions. Table 3.3 indicates that, although the local implications of large-scale climate phenomena were varied, unusual weather conditions were observed across different regencies in the province in 2006.

Table 3.3 Rainfall from November to December in 2005 and from April to May in 2006 relative to the data set of the monthly rainfall from 2004 to 2009 in Tapanuli Selatan and from 2001 to 2009 in three other regencies in North Sumatra (calculated from the monitoring data provided by BMKG North Sumatra)

	Rainfall: Nov.-Dec. (mm)			Rainfall: Apr.-May (mm)		
	2005	Maximum	Minimum	2006	Maximum	Minimum
Labuhan Batu	Data not available	558	434	714	773	179
Tapanuli Selatan	200	668	200	130	337	130
Simalungun	757	976	399	1,229	1,229	295
Langkat	521	675	434	573	573	80

3.3.2. Economic environment

As for the economic environment at the provincial level, time series analyses were conducted with the annual data from BPS between 2000 and 2009. The differences across regencies were assessed using data on rice planting index and irrigation coverage as of 2009, which was provided by the Agriculture Office of North Sumatra.

Oil palm plantations are increasing exponentially, driven by growing demand worldwide. Indonesia has been the world's largest producer and exporter of palm oil since 2008 (Wicke *et al*., 2010). Palm oil has become a highly profitable source of income for those engaged in its production. It also provides considerable revenues to the national and regional governments (McCarthy *et al*., 2012). In addition, the recent government policy, the Master Plan for Acceleration and Expansion of Indonesian Economic Development 2011-2025 (*Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia*, MP3EI), supports expansion by palm oil enterprises into downstream operations, with the island of Sumatra being identified as the strategic location (Coordinating Ministry for Economic Affairs, 2011). With growing demand for palm oil worldwide, the price has been rising. Most notably, it increased threefold from the middle of 2006 to the end of 2007. Despite the October 2008 price slump, world demand for edible oils is expected to further increase during the next 20 years (Sheil *et al*., 2009).

In contrast, the economic environment for rice farmers has been difficult in recent years. According to BPS North Sumatra (2001-2010), the average revenues of farmers from production of food crops, mainly rice, have been almost consistently below their total production costs in North Sumatra. As depicted in Fig. 3.7, rice was imported in 2006 and 2007 in response to the reduction in local rice production. Sawit and Lokollo (2007) find that the low price of imported rice, which mostly comes from Thailand and Vietnam, puts downward pressure on the prices of domestically-produced rice. Even though the government did not import rice in 2008-2009 when international rice prices were higher than domestic rice prices, as will be explained further in Fig. 4.4 in the following chapter, the increases of imported cheap rice in 2006 and 2007 had a negative effect on local rice farmers' production incentives. In addition, BULOG, which is tasked by the government with procurement of rice, has not purchased rice locally produced in North Sumatra since 2005 (communication with BULOG North Sumatra, 2011). This indicates that, from the local rice farmers' perspective, the government floor price has been set too low to sell. At the same time, farmers face rising production costs. According to BPS (2008), for example, the price of urea fertilizers increased by almost 70% from 2000 to 2006.

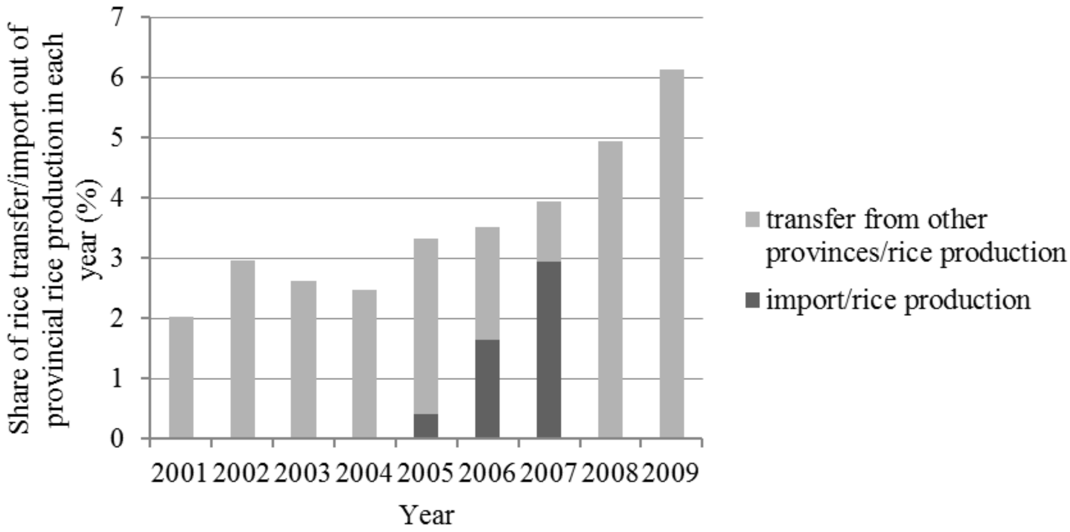

Fig. 3.7 Rice imports and transfers from other provinces relative to rice production in each year in North Sumatra (BPS North Sumatra, 2000-2010)

The combination of these factors provides economic incentives for farmers to convert their land use from rice to oil palm. A comparative analysis of household economy between rice production and oil palm plantation was conducted by Feintrenie *et al.* (2010), based on a study at one district in Jambi, another province in the island of Sumatra, which demonstrates that high returns can be generated by oil palm, making it much more profitable than rice. According to their study, the average returns to land were 2,100 €/ha for oil palm and only 200 €/ha for a paddy field, based on July 2008 prices, where return to land is the net added value generated by one hectare of land during one year. The comparison of returns to labor was even more striking: 36 €/person-day for oil palm and only 1.7 €/person-day for rice, where return to labor is the return to land divided by the number of working hours for one hectare during one year. This study indicates that, while one consequence of the slump in oil palm prices in 2009 was the resumption of rice cropping, as a way to secure food supply in the study site, the profitability of rice cultivation remained lower than that of oil palm.

The difference of profitability is also supported by Fig. 3.8, where the farmers' net terms of trade for food and plantation crops in North Sumatra are illustrated over the last three years, for which period the relevant data was available for this study. In Fig. 3.8, the main food crop is rice, while secondary food crops include maize and cassava. Oil palm is predominant in plantation crops. Rubber, coconut, coffee and other plantation crops are also included, but in considerably smaller quantity, even though the exact share of each crop is unknown for this study. It shows that the net terms of trade for plantation crops were consistently higher than those for food crops except at the end of the year 2008, when the market prices of palm oil fell sharply. Oil palm is more profitable than rice for farmers, even though the productivity growth in rice production is larger than that in palm oil plantation from 2001 to 2009, as shown in Table 3.4.

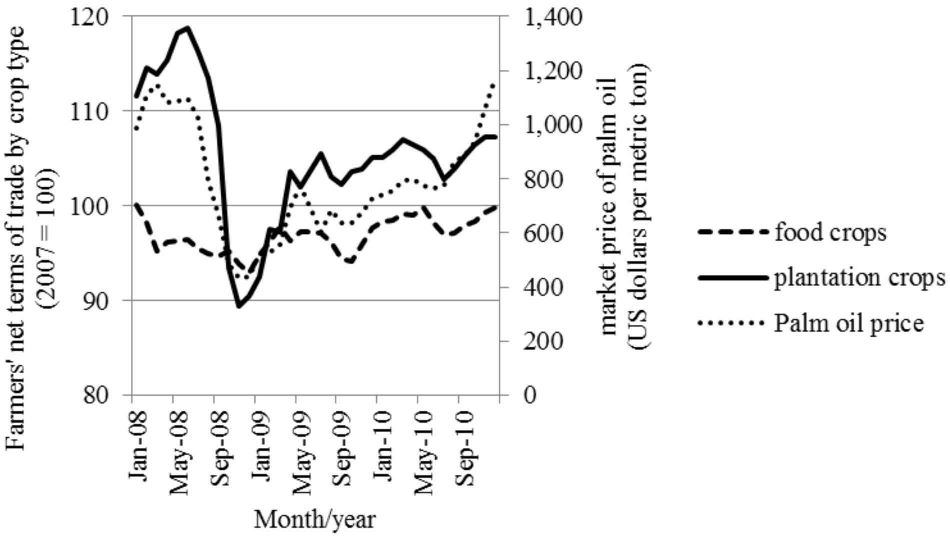

Fig. 3.8 Farmers' net terms of trade by crop type in North Sumatra (BPS North Sumatra, 2009-2011; Index Mundi, 2013)

Table 3.4 Productivity of rice production and oil palm plantation in North Sumatra (BPS North Sumatra, 2001 and 2010)

	Productivity (ton/ha)		Productivity growth (%)
	2001	2009	
Rice production	4.08	4.59	12.41
Oil palm plantation (smallholders) (*)	14.80	15.18	2.67
Oil palm plantation (estate enterprises) (*)	19.30	20.67	7.10

Note: (*) The productivity of oil palm plantation was given by dividing an amount of bunch of palm (ton) by a productive plantation area (ha).

3.3.3. Rice planting index

The rice planting index is the number of planting times per year. This is another major factor that influences farmers' decisions concerning land use conversion. Interviews with government officials and farmers (BAPPEDA North Sumatra, 2011) indicate that the option to stay with rice production instead of converting land use is generally chosen by farmers in locations where rice can be harvested more than twice per year. This observation is shared by Papenfus (2000), who concludes that significant sunk costs and uncertainties add value to the option of 'wait and see', despite his finding that the returns on oil palm are higher than other smallholder activities.

According to the latest data (Agriculture Office of North Sumatra, 2011), however, the area where the planting index is more than two accounts for less than 10% of the total wetland rice fields in the province. This is closely related to the fact that about 40% of the total wetland rice fields in North Sumatra are not irrigated (BPS North Sumatra, 2009b). Rice production in the province remains sensitive to the quantity and timing of rainfall. Under unusual climate conditions, planting becomes even more difficult without irrigation. A lower planting index then means lower economic returns from rice production, thereby adding extra incentives for land use conversion. Land use conversion from rice to cash crops is therefore more likely to take place where irrigation is not well developed or maintained. In a past newspaper article (Medan Bisnis, 2006), for example, farmers in Tapanuli Selatan attributed their decision regarding land conversion to malfunctioning irrigation systems as well as drought conditions. Some interviewees argued that, with too much decentralization in the country, the budget allocated to respective regencies became smaller, thereby making the maintenance of irrigation systems by each jurisdiction even more difficult.

3.3.4. Distance from palm oil enterprise estates

Despite its higher profitability, entering into oil palm production is not an easy decision for farmers. Papenfus (2000) identified four main constraints on individual growers in Indonesia in converting their land to oil palm: uncertainty over market access, lack of technical knowledge, large initial capital outlays, and long-term risk associated with irreversibility of land use decisions and palm oil price volatility. Barlow *et al*. (2003) indicate that the so-called 'nucleus-plasma scheme' has eased these constraints, thereby becoming prevalent in many parts of Indonesia. According to Zen *et al*. (2005), under this scheme, plantation companies support individual growers in a 'plasma' area around their own plantation 'nucleus.' The basic concept is that plantation companies provide the access to the improved seedlings, technical advice, and starting capital that are needed to cover planting and other input costs. This is made available from a commercial nucleus for the surrounding plasma of smallholdings.

Vermeulen *et al.* (2006) also underlines the fact that fresh oil palm fruit bunches must be milled within 24 hours of harvest to avoid deterioration in quality, and therefore smallholders must deliver their harvest to a nearby mill rapidly. In practice, this often necessitates a close relationship with a company that owns mills within delivery distance. Proximity to palm oil enterprise estates is therefore one of the conditions for conversion to oil palm plantation. Palm oil enterprises plan to establish new milling facilities in other parts of the province, as exemplified in the state-owned plantation company (*PT Perkebunan Nusantara,* PTPN) IV (2010). If distance is one impact factor, as discussed above, land use in the area surrounding these new facilities may become subject to change in the future.

In this section, four factors have been examined as those affecting rice farmers' decisions regarding land use conversion: (1) climate conditions, (2) economic environment, (3) rice planting index, and (4) distance from palm oil enterprise estates. Unusual climate conditions were observed across different regencies in North Sumatra, as was the case in 2006. Economic conditions, such as the price difference between oil palm and rice, which incentivized land use conversion, also existed in common across the province. However, the remaining two factors - rice planting index and the proximity to palm oil enterprise estates - varied across regencies, which differentiated rice farmers' response to the climate and economic conditions they commonly faced. While other possible factors may exist, such as soil quality as well as pest and weed impacts (Westhoff, 2010), the relevant data is not available for this study.

These four factors have different characteristics. While factor (1) was most notable in 2006, the other three factors had existed for a longer time horizon. One interpretation is that the climate impacts interacted with the other underlying factors and triggered the land use conversion, which was most phenomenal in 2006. Factor (3) may be regarded as a part of factor (2): The relative profitability of oil palm over rice will be even greater as the rice planting index gets lower. Factor (4), on the other hand, can be considered as a conditional factor: Even where the economic incentive to convert land use is strong, it cannot be realized if the farmland concerned is beyond the distance for delivery of oil palm fruit bunches to mills.

3.4. Regional difference in farmers' response

The four target regencies - Labuhan Batu, Tapanuli Selatan, Simalungun and Langkat - were selected because of their geographical differences, which were expected to lead to differentiated responses in North Sumatra. The following part will examine how farmers responded in each regency, and what made the differences. For comparison among the four regencies, the ratio of oil palm-planted area and rice harvest area is used for each year, as shown in Fig. 3.9.

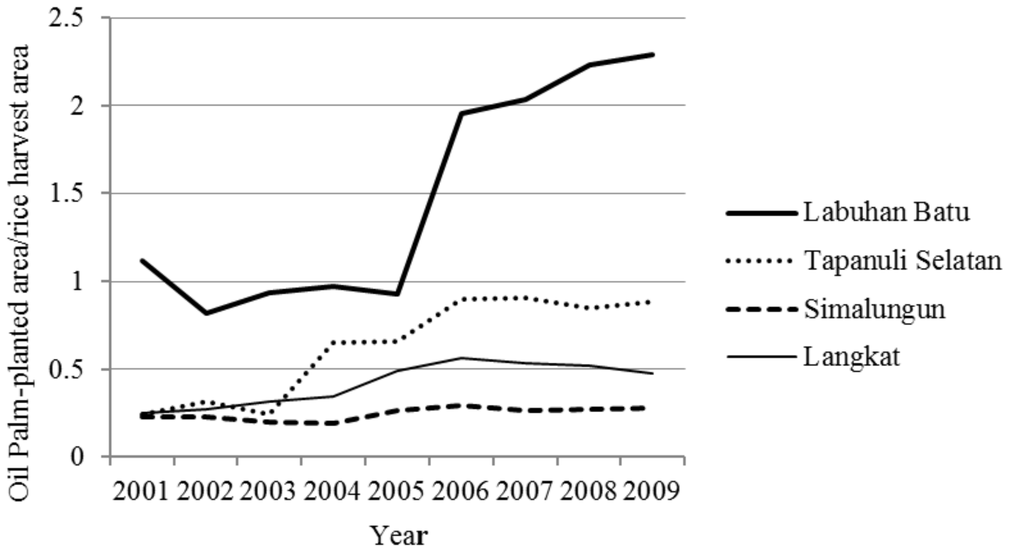

Fig. 3.9 Oil palm plantation area/rice harvest area in each year in four regencies in North Sumatra (original data from BPS North Sumatra, 2000-2010)

Figure 3.9 illustrates that, in Labuhan Batu, the ratio of oil palm-planted area to rice harvest area sharply increased in 2006 and continued to climb thereafter. In fact, the recent data (Agriculture Office of North Sumatra, 2010) shows that the rice-planted area in the regency decreased by more than half from 122 thousand hectare in 2005 to 58 thousand hectare in 2009.

Labuhan Batu is one of the major oil palm plantation areas in North Sumatra. Palm oil enterprises are concentrated in the eastern coastal area because of its strategic location facing the Malacca Strait. The concentration of enterprise estates guarantees close distances from smallholders to mills. Large-scale land use conversion from rice to oil palm has been made possible under this condition. Even in the case of Labuhan Batu, however, farmers do not give up rice production completely. As indicated by Vermeulen and Goad (2006) and Zen *et al*. (2005), production of palm oil is the ‘core business’ for large plantation companies, but for smallholders, oil palm is just one means of making a living. This is related to what Dove (2011) calls ‘dual household economy’. He finds a division within the household between two fundamentally different types of production: one oriented toward meeting the household’s subsistence needs, and the other oriented toward meeting market needs.

Figure 3.9 also shows a substantial increase in oil palm-planted area relative to rice harvest area by 2006 in Tapanuli Selatan. The level of increase, however, is more modest than in Labuhan Batu. In addition, it has been stable since 2006. Instead, the growth in rubber plantation is more notable in this regency. According to BPS North Sumatra (2006-2010), the rubber-planted area increased by about 23 thousand hectare from 2005 to 2009, while the rice harvest area decreased by about 18 thousand hectare during this period.

Tapanuli Selatan is located in the highlands, far from the east coast of North Sumatra, where palm oil enterprise estates are concentrated. This physical condition makes it more difficult for the nucleus-plasma scheme to be established and operate sustainably in the regency. For the majority of farmers, mills are not within the required distance for delivery of oil palm fruit bunches. Entering into oil palm plantation is, therefore, a much more difficult decision for farmers in Tapanuli Selatan than Labuhan Batu.

Finally, Fig. 3.9 shows more stable relations between rice harvest area and oil palm-planted area for both Simalungun and Langkat. Like Labuhan Batu, Simalungun experienced unusually wet conditions in 2006 and the rice harvest area dropped. Unlike Labuhan Batu, however, the decrease was only temporary. By 2009, the rice harvest area had been restored.

Simalungun is widely regarded as the center of rice production in North Sumatra. As Table 3.5 shows, about half of the technical irrigation in the province is concentrated in Simalungun. Consequently, the yield rate of rice is 5.1 kg/ha, the top among all the regencies in the province (BPS North Sumatra, 2010). The planting index in the regency is also more than two (Agriculture Office of North Sumatra, 2011). Therefore, although Simalungun is within the distance for delivery of oil palm fruit bunches to mills, less economic incentives exist for farmers to give up rice production in order to start cash crop cultivation.

Langkat is similar to Simalungun in terms of farmers' response, as shown in Fig. 3.9. Even though it is largely rain-fed, the planting index in most parts of the regency is more than two. According to the Agriculture Office, this is mainly due to soil fertility, although the relevant statistics are not available for confirmation. With the rice planting index being relatively high, farmers in Langkat have less economic incentives to give up rice production.

As Table 3.5 indicates, however, in the majority of the rain-fed area in the province, the planting index is less than two, which generally gives more economic incentives for land use conversion. Therefore, infrastructure development such as irrigation is important as an adaptation measure for climate change and extreme events.

Three types of farmers' response are identified by the present study: (1) land use conversion from rice production to oil palm plantation, (2) land use conversion to other cash crops, and (3) staying with rice production. Type (1) is observed in Labuhan Batu, type (2) in Tapanuli Selatan, and type (3) in Simalungun and Langkat. Rice farmers' responses are differentiated across the regencies according to their geographical and socio-economic conditions, as illustrated in Fig. 3.10.

Table 3.5 Technical irrigation and rain-fed area by rice planting index in North Sumatra (Agriculture Office of North Sumatra, 2010)

	Technical irrigation (ha) by rice planting index			Rain-fed (ha) by rice planting index		
Planting index	Over 3	2-3	1-2	Over 3	2-3	1-2
Labuhan Batu	-	1,987	-	-	4,320	39,427
Tapanuli Selatan	1,615	5,040	-	-	30	11,542
Simalungun	-	37,956	-	-	7	85
Langkat	-	3,642	-	1,000	24,509	5,832
North Sumatra (total)	1,645	70,319	1,225	1,669	68,666	89,645

3.5. Conclusion

The present study revealed that the consistent increase in rice productivity has been offset by the reduction in rice harvest area, resulting in almost no growth in rice production over the last decade in North Sumatra. In contrast, oil palm plantations, particularly smallholder estates, have been expanding in the province. Four factors were identified as affecting the change in land use: (1) climate conditions, (2) economic environment, (3) rice planting index, and (4) distance from palm oil enterprise estates. The climate impacts interacted with the other underlying factors and triggered land use conversion, which was most phenomenal in 2006. When unusual climate conditions were observed across different regencies in North Sumatra such as in 2006, the rice harvest area substantially decreased. Economic conditions, such as the price difference between oil palm and rice, which incentivized land use conversion, also existed in common across the province. However, the remaining two factors - rice planting index and the proximity to palm oil enterprise estates - varied across regencies, which differentiated the rice farmers' response into three types: (1) land use conversion from rice production to oil palm plantation, (2) land use conversion to other cash crops, and (3) staying with rice production.

In a study based on the 20 km mesh climate model of the Meteorological Research Institute of Japan, Kitoh *et al.* (2010) find that the annual total rainfall is projected to increase in the coastal area while decreasing in the highlands in the northern part of Sumatra. According to this study, the frequency and intensity of climate anomalies are also projected to increase in northern Sumatra. This indicates that the unusual climate conditions observed in 2006 will occur more frequently in the future. The unusual weather events in 2006 may have triggered the reduction of rice production and land use conversion. If climate anomalies become more frequent, there will be an increasing likelihood that socio-economic pressure to change land use from rice to other cash crops is exacerbated. Therefore, proactive adaptation by decreasing the vulnerability of rice production to climate variability and change is an important policy for food security in North Sumatra. This should also be the case for Indonesia in general.

At the same time, the three types of farmers' response identified in this study illustrate how climate impacts affect communities differently. Even though they all faced unusual climate conditions, their responses were different across regencies. Climate is not the single causal agent. Instead, vulnerability occurs as a result of a multitude of physical, social and economic processes. The case in North Sumatra illustrates that factors differentiate vulnerability, such as the availability of irrigation services and the distance to palm oil mills. A lack of understanding of the differential nature of vulnerability and opportunities may result in incorrect judgments for planning countermeasures.

This study also shows that, while rice and oil palm compete for land use, climate impacts may undermine the equilibrium of the competition. In the case of Labuhan Batu, for example, climate events increased the competitive advantage of oil palm over rice. As oil palm is more resilient to rainfall variability, land use conversion from rice production to oil palm plantation can be considered a good adaptation from the farmers' perspective. The large scale of the conversions, however, may be a threat to the food security of the society as a whole. This indicates that countermeasures face trade-offs between different social groups, as well as between various adaptation actions, and between adaptation and other development priorities.

This study also revealed the necessity for further research on the policy, institutional mechanisms and procedures for resolving the above-mentioned trade-offs. In this context, criteria and indicators for assessing and prioritizing these trade-offs need to be developed.

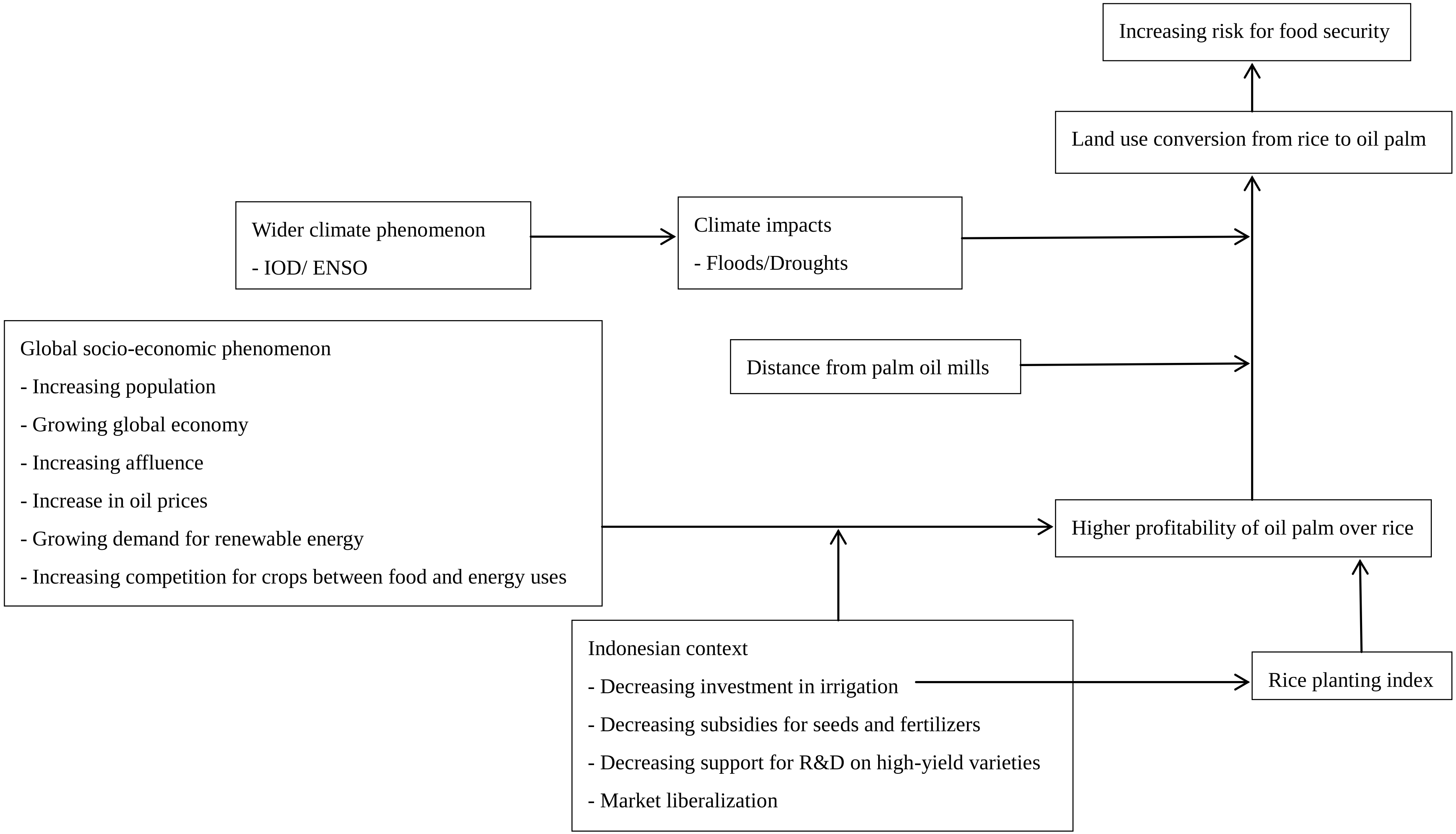

Fig. 3.10 Interactions of climate impacts with socio-economic factors to trigger land use conversion from rice to oil palm (produced by the author)

4. Adaptive Response of Rice Markets to Climate Impacts: A Case Study in East Java and East Nusa Tenggara

4.1. Introduction

Rice is the staple food for most of the people in Indonesia. It is also an important part of the rural economy. While 38% of rural households produce rice, many more are connected to the rice economy through services, labor and trade. Getting the rice policy right is therefore essential for achieving food security, as well as providing income and employment opportunities in rural areas (McCulloch and Timmer, 2008). This is challenged, however, by the sheer size and heterogeneity of the country. According to BPS (2011), Indonesia has a population of 238 million as of 2010, the fourth largest in the world, and with more than 17,000 islands, it is also highly diverse in terms of climate as well as social and economic conditions.

Climate impacts on paddy production and its response in Indonesia have been the subjects of several studies (Amien *et al.*, 1999; Keil *et al.*, 2009; Kawanishi and Mimura, 2013a). Little has been examined, however, as to climate impacts on rice distribution, even though food availability relies upon not only production but also distribution channels to get food where it needs to be, as elaborated by Ericksen *et al*. (2010). In this respect, Van der Eng (2010) assessed how rice markets responded to variations in rainfall during 1935-40 in Java. This study used local rainfall data to assess the impact of variability of rainfall on fluctuations in paddy production across 19 regencies in Java. The paper then examined local rice price data to assess the responses of rice markets to the fluctuations in paddy production in these regencies. The study found that rice markets were highly integrated across Java. The unusually low rainfalls in 1935 and 1940, associated with El Nino, caused deficiencies in paddy production in some locations. They did not have a negative effect, however, on variations in rice prices across Java. The finding suggests that the rice markets worked to mitigate food deficiencies in areas affected by shortage of rainfall and falling paddy production. The study shows that, if well integrated, the market is able to adapt autonomously to climate stress by providing incentives that direct flows of rice from surplus to deficit areas.

Building upon the above finding, this chapter has two objectives. Firstly, it aims to understand the status and change in rice distribution between provinces in Indonesia, and their associated climate and economic factors. Secondly, it will examine whether autonomous adaptation exists in rice markets. To this end, monthly inflation rates of food over the last ten years are analyzed between different locations. This paper targets the rice distribution between Surabaya and Kupang, the provincial capitals of East Java and NTT, respectively. These two provinces are chosen as target sites for the following reasons. Firstly, while East Java has a surplus of rice, NTT has a chronic deficit due to a short rainy season and a poor irrigation infrastructure, among other factors, as will be described later. Secondly, according to Varela *et al*. (2012), the rice markets in the two provinces are one of the most strongly integrated pairs in Indonesia. The Institute of Economic and Social Research, Faculty of Economics, University of Indonesia (*Lembaga Penyelidikan Ekonomi dan Masyarakat, Fakultas Ekonomi, Universitas Indonesia*, LPEM-FEUI) and the Asia Foundation (2010) also document that most goods directed to NTT are transported by sea through Surabaya.

Note:
This chapter was presented at the 9th International Symposium on Social Management System, which took place from 2 to 4 December 2013 in Sydney, Australia (Kawanishi and Mimura, 2013b).

4.2. Methods

A time series analysis from 2001 to 2010 was made on rice transfer from East Java to NTT, along with changes in rice prices, using data from BULOG, BPS and OECD. Climate impacts, particularly impacts of rainfall during wet seasons, on paddy production in NTT were also examined, using data from BMKG.

On adaptive responses of distribution between Surabaya and Kupang, monthly inflation rates of food in these two cities from 2002 to 2010, with the total number of pairs being 108, were utilized. Using rice price as an indicator of market adaptive responses, Van der Eng (2010) showed that the market, if well integrated, is able to adapt by providing price signals to direct flows of rice from surplus to deficit areas, as persistent price differences between locations imply weak supply responses to higher prices. For the present study, data on monthly inflation rates specifically for rice in these two cities was not available. Instead, data on monthly inflation rates of food items, available from BPS, was utilized. Cereals, in particular rice, are the dominant item in this data, even if its share is not clearly specified by BPS. Other items include vegetables, beans, fruits and spices. A cross-correlation analysis was conducted on the monthly inflation rates between these two cities. The relationship between these two data sets was then analyzed in the scatter diagram.

A seasonal change in the ability to supply rice in East Java was gauged by the data on monthly rice stock at BULOG East Java, while that in the purchasing power in NTT was measured by the data on monthly net farmers' terms of trade, available from BPS NTT. As sea transport is a dominant mode for transportation of food between the two cities, the impact of wind velocity on food price differences between them was also analyzed in the scatter diagram, using data on monthly wind velocity in Surabaya, available from BPS. The corresponding data in Kupang was only available for very recent years. Other potentially relevant data, such as the number of navigational warnings and ship accidents, was only available on an annual basis for this study. Kupang was visited in January

2013 to obtain a general understanding of its climate and socio-economic conditions.

4.3. Status and trend of rice distribution in Indonesia

4.3.1. Overview of East Java and NTT

East Java, one of the provinces in the Island of Java, is located at 7°1'-8°5' south latitude and 111°0'-114°4' east longitude with a land area of nearly 48 thousand km^2 and a population of 37.5 million, predominantly Muslim (BPS East Java, 2010a). The provincial capital is Surabaya, whose population is about 2.6 million according to its census in 2000 (BPS Kota Surabaya, 2010). The intra-annual rainfall pattern in East Java is characterized by one peak and one trough with an influence of two monsoons, namely the wet northwest and the dry southeast monsoons. Accordingly, it has two seasons: wet from November to May, and dry from June to October. As for inter-annual climate variations, like most other parts of Indonesia, East Java is influenced by ENSO. The agricultural sector accounts for 15% of the provincial GDP, with rice being by far the most important crop. As of 2010, the area of wet paddy field is around 1.2 million hectare, nearly 80% of which is irrigated with a varying degree of technical sophistication.

NTT (Fig. 4.1) is located at the eastern end of Indonesia, at 8°-12° south latitude and 118°-125° east longitude with a land area of nearly 47 thousand km^2, spreading over 1,192 small islands, four of which are relatively larger: Flores, Sumba, Timor and Alor. Most of the land is mountainous and hilly. The capital is Kupang, whose population is 0.3 million in 2011 (BPS Kota Kupang, 2012). The province has longer dry and shorter rainy seasons than other parts of the country, with its wet season spanning only four months from December to March. It has a population of 4.7 million, predominantly Christian, with a poverty rate 21%, much higher than the national average 12% (BPS NTT, 2011). The malnutrition rate among children is also high. The agricultural sector accounts for 37% of the provincial GDP. As presented by Muslimatun and Fanggidae (2009), and Salim (2010), while rice and maize are the two most important crops, rice is increasingly considered to be the main food staple of households. It also gives prestige to those who consume it.

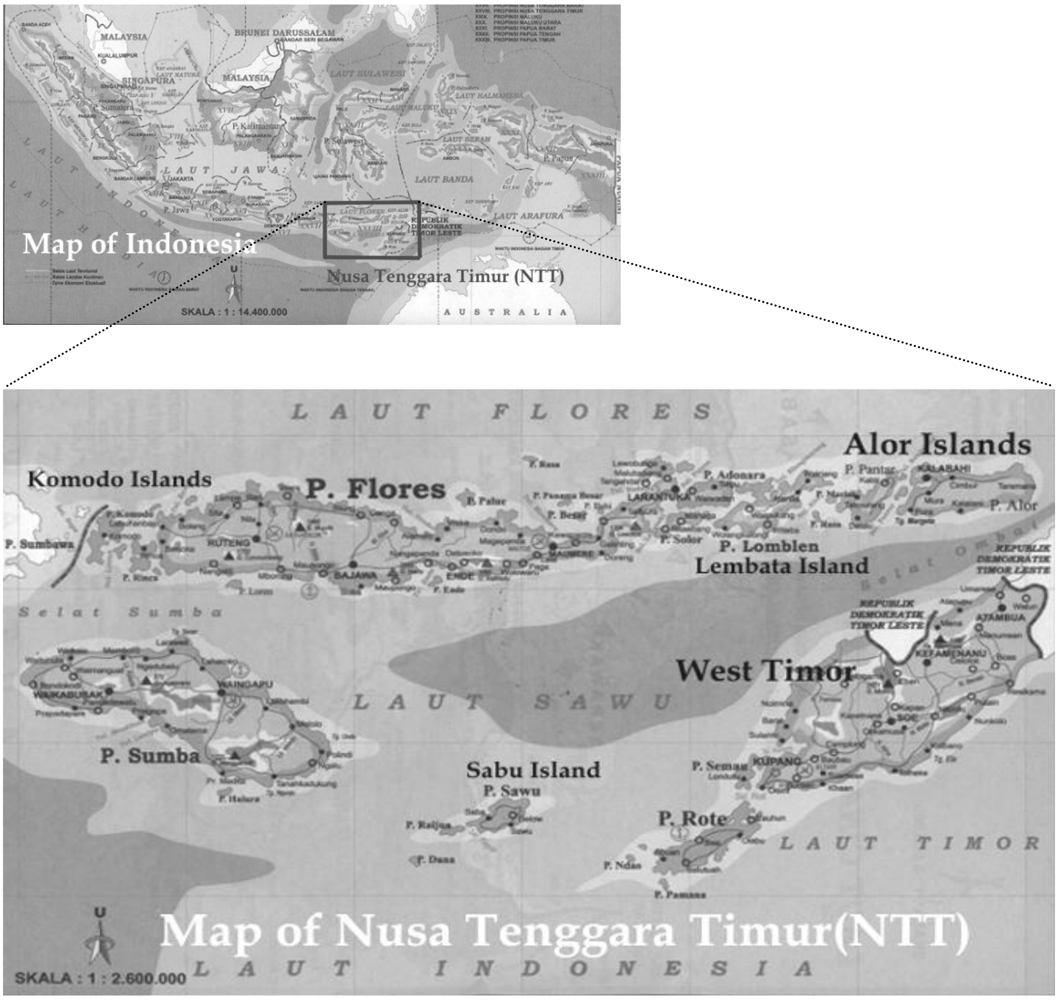

Fig. 4.1 Map of NTT (cited from Provincial Tourism Department of NTT, 2013)

4.3.2. Logistics and infrastructure in NTT

The World Bank's Logistics Performance Index (LPI) for 2012 ranked Indonesia 59th out of 155 countries, behind neighboring countries such as Singapore, Malaysia, Thailand and the Philippines. Indonesia is worse than or equal to these four countries in all categories except timeliness, where Indonesia performs slightly better than the Philippines, as shown in Table 4.1.

Maritime operations play a significant role in logistics in an archipelagic country such as Indonesia. They may be disrupted, however, due to higher wind speeds as well as increases in wave, sea and tidal levels, which have a range of negative impacts on ports and navigational channels, as summarized in Table 4.2. Gerning *et al*. (2010) found that climate-related disruptive impacts on maritime operations were considerable in Indonesia during the period from 2006 to 2009. As presented in Table 4.3, the numbers of both navigational warnings and ship accidents increased year by year. It also indicates the worsening of port operations.

As described in LPEM-FEUI and the Asia Foundation (2010), with an ocean area of 200,000 km^2, roughly four times the land area (47,000 km^2), and a coastline of 5,700 km, sea and ferry transportation plays a very important role in NTT. Most trade in goods, both between provinces and within the province, requires the use of more than one mode of transportation. Consequently, road and port infrastructure issues are critical in supporting transportation performance in this province.

NTT has five commercial seaports, including the Port of Tenau in Kupang, all of which are managed by the Indonesian Port Company (*PT Pelabuhan Indonesia*, PT PELINDO) and regulated by the government through the Port Administrator (*Administrasi Pelabuhan*, ADPEL). Non-commercial ports are managed directly by the government. Generally, NTT's transportation infrastructure is limited. Of the five commercial seaports in NTT, only the Port of Tenau (Kupang) can accommodate large vessels of up to 10,000 dead weight tons (DWT) with container facilities, even though it still lacks facilities such as gantry cranes. Other seaports have much smaller maximum capacities (less than 2,000 DWT). While the Port of Tenau has five piers, most of the other ports have only one pier, which means that vessels must queue to dock more often than otherwise. Facilities such as warehouses and stacking areas are still limited at most seaports. As for road infrastructure, while national highways are generally in good condition, the coverage and quality of roads under the management of regency and city is still poor. (LPEM-FEUI and the Asia Foundation, 2010)

NTT is highly dependent on other regions of Indonesia, especially Surabaya. Most goods going to NTT are transported by ship from Surabaya to Kupang. Conversely, most goods from all parts of NTT destined for Surabaya and other places outside NTT pass through Kupang. While the Port of Tenau in Kupang is increasingly recognized as a regional hub for NTT, the Port of Tanjung Perak in Surabaya serves various cargo transport routes to eastern parts of Indonesia. Makassar in South Sulawesi also supplies goods to NTT, especially general cargo, but in considerably smaller quantities than Surabaya. Ships are preferred for inter-province trade because the route between Surabaya and Kupang is long and the costs are relatively low. However, trucks and ferries are the preferred mode when goods are transported to and from the western part of the island of Flores, which is relatively closer to Surabaya. (LPEM-FEUI and the Asia Foundation, 2010)

Weather conditions in NTT do not support regular year-round sailing. Strong winds and high waves occur in January and February, reducing the frequency of crossings. LPEM-FEUI and the Asia Foundation (2010) surveyed two routes, one from Kupang to Rote, a route to cross the Strait of Rote, and the other from Kupang to Larantuka, which is located at the eastern tip of the Island of Flores, for two years from 2008 to 2009. They found that the average frequency of crossings in

January and February between Kupang and Rote is 65% of the average from March to December. The route between Kupang and Larantuka is even worse, with a frequency of crossings in January and February being only 44% of the average for the other months, disrupting the distribution of goods and increasing transportation costs in NTT. They also found a high correlation between the number of days when wind speeds exceeded 10 knots per hour and the frequency of crossings for the two routes surveyed.

Table 4.1 Logistics Performance Index 2012: Comparison with neighboring countries (World Bank, 2013b)

	Global rank	Total score	Customs	Infrastructure	International shipments	Logistics competence	Tracking & tracing	Timelines
Singapore	1	4.13	4.10	4.15	3.99	4.07	4.07	4.39
Malaysia	29	3.49	3.28	3.43	3.40	3.45	3.54	3.86
Thailand	38	3.18	2.96	3.08	3.21	2.98	3.18	3.63
Philippines	52	3.02	3.02	2.80	2.97	3.14	3.30	3.30
Indonesia	59	2.94	2.94	2.54	2.97	2.85	3.12	3.61

Notes:

1) Customs: Efficiency of the clearance process (i.e., speed, simplicity and predictability of formalities) by border control agencies, including customs
2) Infrastructure: Quality of trade and transport-related infrastructure (e.g., ports, railroads, roads, information technology)
3) International shipments: Ease of arranging competitively-priced shipments
4) Logistics competence: Competence and quality of logistics services (e.g., transport operators, customs brokers)
5) Tracking & tracing: Ability to track and trace consignments
6) Timeliness: Timeliness of shipments in reaching destination within scheduled or expected delivery time

Table 4.2 Climate phenomena and impacts on maritime operations (cited from Gurning and Cahoon, 2009)

Climate phenomena	Impacts	Port	Inter-island shipping	In-land road	Coastal area
Increased wind speed	Increased vulnerability of structures	x			x
	Reduced working hours of port equipment	x			
	Reduced capacity of port service	x	x	x	
	Increased wave agitation in port basin	x			
Higher wave level	Increased overtopping to decks and jetties	x			
	Reduced regularity of the port	x			
	Increased port damage	x			
	Vessel speed reduction		x		
	Detour of shipping route	x	x		
	Frequent shipping delay		x		
Increase in sea level	Problems with bridge clearance		x		
	Low land flooding	x		x	x
	Congestion at port road, influencing accessibility	x		x	
Higher tidal level	Problems in ship's maneuvering	x	x		
	Increased damage to coastal channel	x	x		x
	Changed dredging requirements	x			

Table 4.3 Climate impacts on maritime operations in Indonesia (cited from Gerning *et al.*, 2010)

Maritime operational impacts	Year			
	2006	2007	2008	2009
Navigational warnings	2	3	7	12
Longer lead time for food-based products (days)	14	22	28	30
Port closure of two main ports in Java and one port in Sulawesi (days)	1	4	7	14
Ship accidents mainly due to higher level of waves	1	2	6	9
Port loss due to service unavailability (%)	2.5	4	5	10

Table 4.4 as compiled by the United Nations Conference on Trade and Development (UNCTAD) shows that adaptation options for ports and their hinterland connections include structural measures, such as raising the elevation of infrastructure in face of sea level rise, as well as non-structural measures, such as emergency management planning against extreme weather conditions. Given the uncertainties in climate change projection, it is difficult to determine the detailed specifications for particular structural responses. In this respect, Isobe (2013) proposed an iterative assessment and responses by taking account of allowances due to the safety factor of structural strength, as well as newly emerging findings as to projected sea level rise and increase of other external forces in the lifetime of the structures.

Table 4.4 List of adaptation measures for ports (cited from UNCTAD, 2011)

Climate impacts	Adaptation measures
Rising sea levels - Flooding and inundation - Erosion of coastal areas	- Relocation, redesign and construction of coastal protection schemes (e.g., levees, seawalls, dikes, infrastructure elevation) - Insurance - Strengthening and elevation of infrastructure (e.g., ports and harbor facilities) - Reduction or avoidance of development/settlement in coastal flood-prone areas though economic incentives and regulation - Provision for evacuation routes and operational plans - Preparation for service delays or cancellations - Adjustments to speed and frequency of service
Extreme weather conditions - Hurricanes - Storms - Floods - Increased precipitation - Wind	- Integration of emergency evacuation procedures into operations - Setting up of barriers and protection structures - Relocation of infrastructure - Ensuring functioning of alternative routes - Greater monitoring of infrastructure conditions - Restriction of development and settlement in low-lying areas - Construction of slope-retention structures - Preparation for service delays or cancellations - Adjustments to speed and frequency of service - Strengthening of foundations, and raising dock and wharf levels - Smart technologies for abnormal event detection - New design for sturdier ships - Development of new design standards for hydraulic structures such as drainage channels

	- Better land use planning in flood-prone areas - Construction of storm retention basins for flash flooding
Rising temperatures - Increases in very hot days and heat waves - Melting ice - Large variations (spatial and temporal) - Frequent freeze and thaw cycles	- Greater use of heat-resistant construction and materials - Continuous inspection, repair and maintenance - Monitoring of infrastructure temperatures - Adjustments to cargo loads - Adjustments to speed and frequency of service - Preparation for service delays or cancellations - Refrigeration, cooling and ventilation systems - Insulation and refrigeration - Modal shift - Transit management scheme, and regulation of navigation in northern regions - Ship design, skilled labor, and training requirements - Development of new designs for building transportation systems on less stable soils

4.3.3. Status and trend of rice distribution between provinces

The trend in paddy production in NTT along with rainfall amount during the wet season in Kupang is depicted in Fig. 4.2, where a strong influence of rainfall during the cropping season on paddy production is observed. This reflects low irrigation coverage and high reliance on rain-fed harvesting in NTT. The proportion of irrigated land, including that which is primitively irrigated, of the total agricultural land in the province, is less than 4% as of 2010 (BPS NTT, 2011). Figure 4.3 shows the change over the last decade in rice distribution to NTT. Comparison between Fig. 4.2 and Fig. 4.3 indicates that the trend in rice transfer from outside the province, including imports, is not necessarily associated with a change in paddy production in NTT. Instead, rice was imported when domestic rice prices were higher than international prices in 2002, and from 2006 to 2007. This is also the case for imports at the national level, as indicated in Fig. 4.4. The timing and volume of imports were not linked with a trend in national paddy production. Instead, imports were made when domestic prices exceeded the international level. These fell upon the years of El Nino. While multiple factors existed for price increases, as discussed by Dawe and Slayton (2010), rice prices increased partly in anticipation of El Nino-induced harvest failure. On the other hand, as shown in Fig. 4.3, domestically-procured rice, in particular from East Java, flowed into NTT significantly from 2008 to 2009, despite increasing paddy production in the province, when global prices significantly increased and imports were terminated.

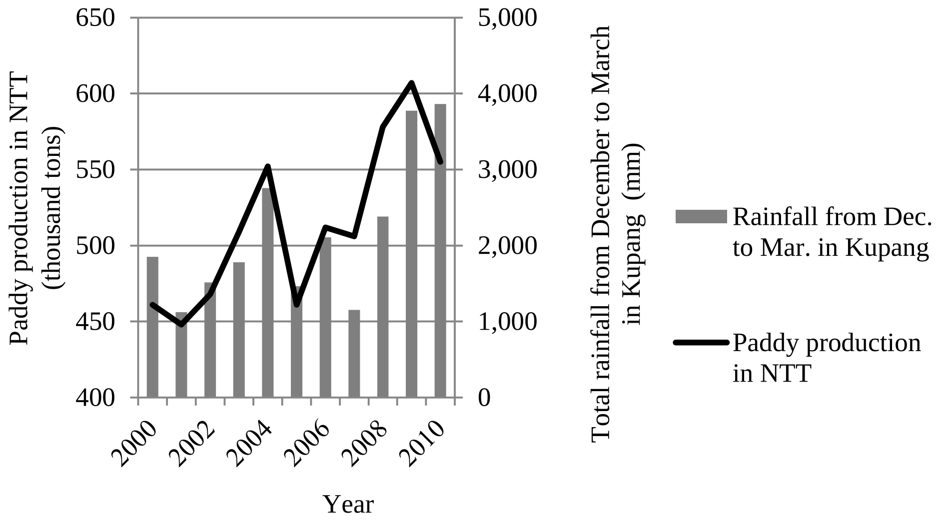

Fig. 4.2 Paddy production and rainfall in NTT (BPS NTT, 2001-2011; BMKG, 2012)

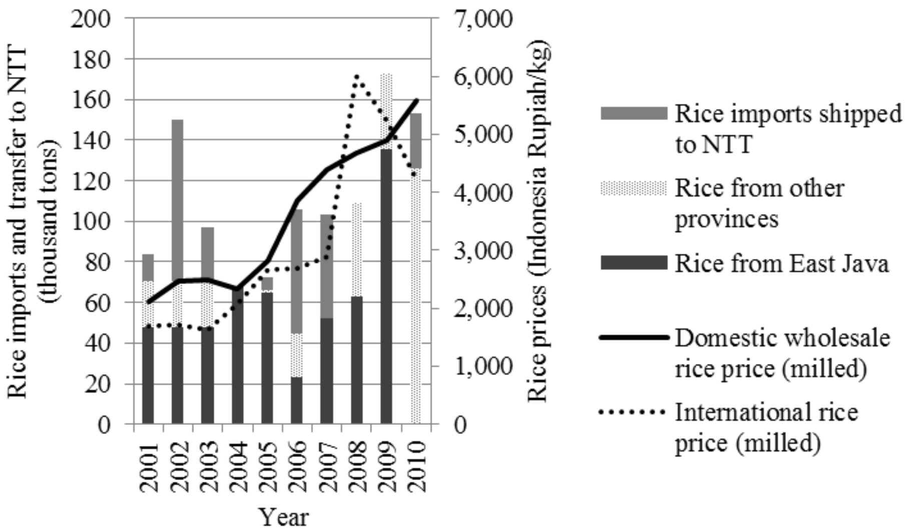

Fig. 4.3 Rice imports and transfer to NTT, with domestic and international rice prices (BPS NTT, 2002-2011; BULOG, 2011; OECD, 2012)

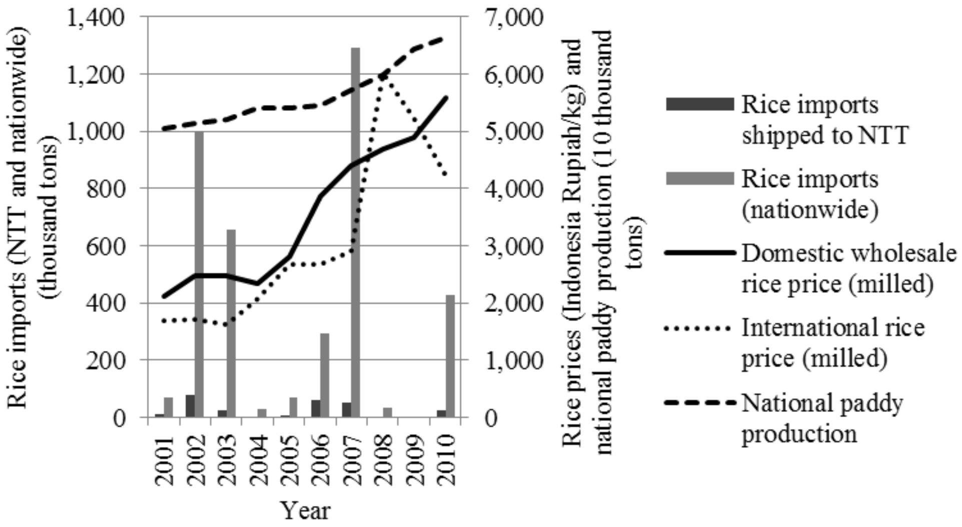

Fig. 4.4 Rice imports to NTT and the whole country, with domestic and international rice prices and national paddy production (BPS, 2002-2011; BPS NTT, 2002-2011; BULOG, 2011; OECD, 2012)

Thus, with a short dry season and lack of irrigation, NTT has a chronic deficit of rice, relying upon others for supply. The trend in rice transfer from outside the province, including imports, is not necessarily associated with a change in paddy production in NTT. Instead, it is more affected by a change in domestic and international rice prices, indicating a strong supply response to higher prices of rice.

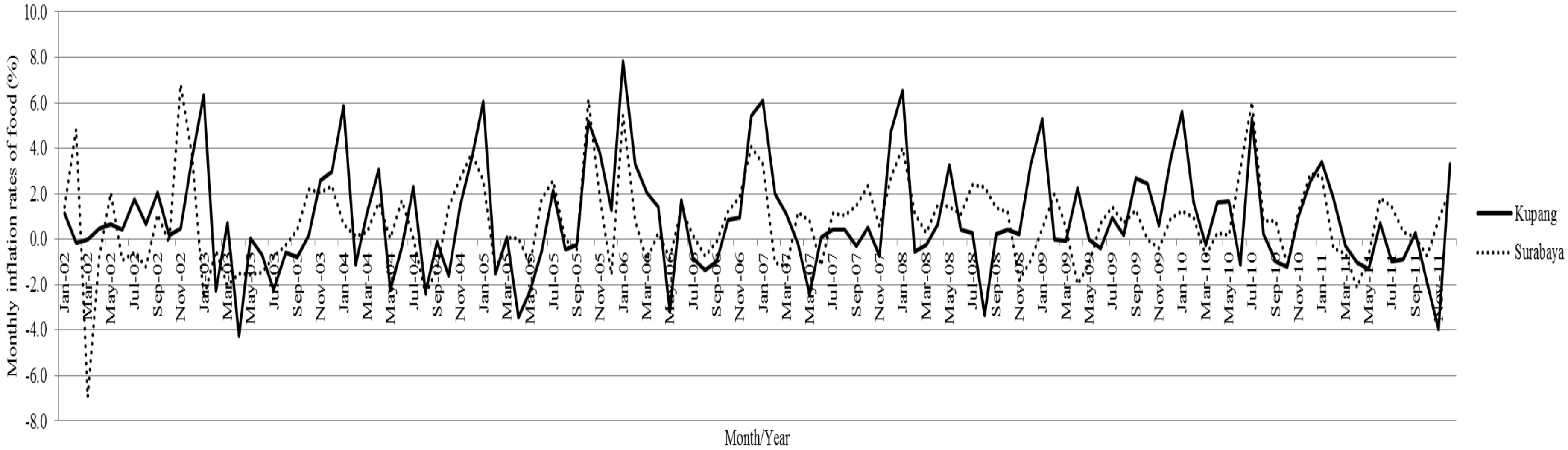

Fig 4.5 Monthly inflation rates of food in Surabaya and Kupang (BPS East Java, 2002-2011a; BPS NTT, 2002-2011)

4.4. Seasonality in correlation of rice markets

4.4.1. Seasonality in correlation of rice markets

A cross-correlation analysis was conducted on the monthly inflation rates of food items between Surabaya and Kupang from January 2002 to December 2010, as shown in Fig. 4.5. It found that the correlation is highest at 0.42 when neither of the two data sets is shifted on the time horizon, as illustrated in Fig. 4.6. This indicates that there is no significant time lag of price movements between the two cities. Figure 4.7 illustrates average food inflation rates by month with the following two findings. Firstly, the intra-annual variation in price changes is similar in both cities. The average inflation rates are higher around December and January before harvesting, while they are lower or even negative between March and June after harvesting. This is linked with the cycle of wet and dry seasons, which regulates the timing of planting and harvesting. Secondly, the average inflation rate in January in Kupang (5.6%) is significantly higher than that in Surabaya (1.7%).

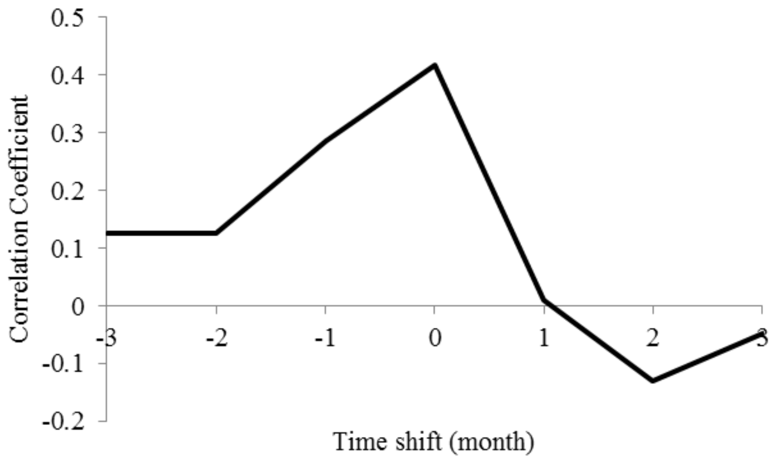

Fig. 4.6 Correlation of monthly inflation rates from 2002 to 2010 between Surabaya and Kupang, where plus one on the horizontal axis indicates that one of the data sets is shifted on the time horizon so that Kupang is behind Surabaya by one month (original data from BPS East Java, 2002-2011a; BPS NTT, 2002-2011)

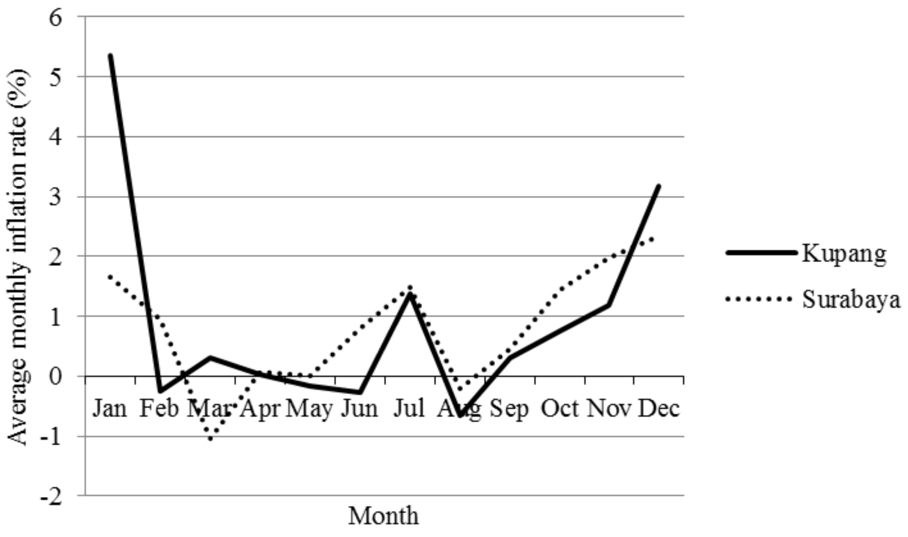

Fig. 4.7 Average inflation rates of food by month from 2002 to 2010 in Surabaya and Kupang (original data from BPS East Java, 2002-2011a; BPS NTT, 2002-2011)

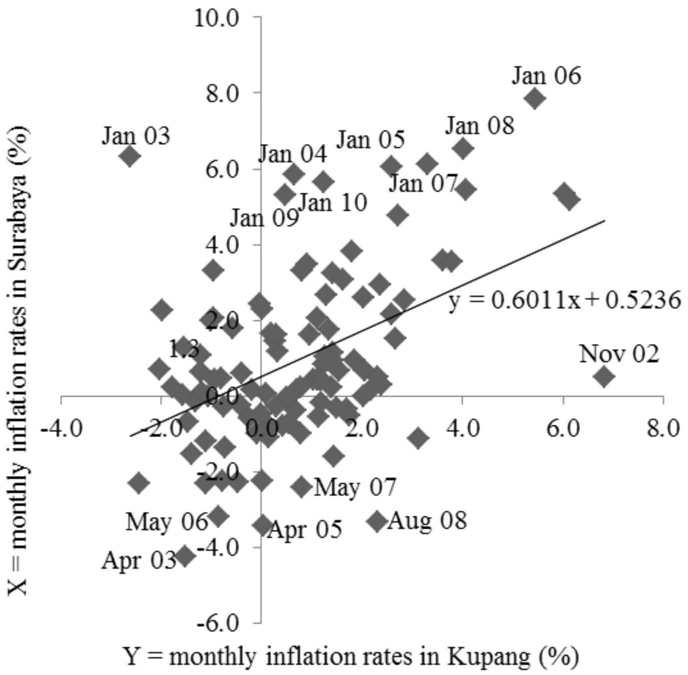

Fig. 4.8 Scatter plots of monthly inflation rates of food in Kupang against those in Surabaya from January 2002 to December 2010 (original data from BPS East Java, 2002-2011a; BPS NTT, 2002-2011)

Figure 4.8 displays plots of monthly food inflation rates in Kupang against those in Surabaya, where neither of the two data sets is shifted over the time horizon as no significant time lag in price movements is found between the two cities. The plots far above and below the approximation line are dated, with the following findings. Firstly, a positive relationship of monthly inflation rates between the two cities is observed. Secondly, the plots which are far above are all dated January each year, affirming consistently high inflation rates for this month in Kupang. A positive relationship is also observed among those plots dated January, with their approximation line being expressed by $y=0.2252x+5.2244$. For the remaining months, on the other hand, it is expressed by $y=0.4143x+0.2846$. This indicates a tendency that the inflation rate in Kupang would be higher by 5% in January than in other months. Thirdly, the plots which are far below include those dated April and May when rice becomes available in the market after harvesting.

4.4.2. Intra-annual factors for seasonality in correlation of rice markets

As documented by Basu and Wong (2012), NTT suffers from a predictable annual hunger period, locally known as *musim paceklik* (famine season) before harvesting. Van der Eng (2010), on the other hand, found that the market is able to mitigate food deficiencies by providing price incentives that direct flows of rice from surplus to deficit areas. If this were the case, the predictable annual hunger period would be avoided through supply response to higher food prices. Van der Eng (2010) identified some conditions under which markets may mitigate food deficiencies. Firstly, there should be a surplus area. Secondly, the population in a deficit area should have the means to purchase food from a surplus area. Thirdly, societies should have sufficiently developed communication and transport facilities to facilitate trade. The validity of these conditions will be examined below in the context between Surabaya and Kupang.

In terms of the first condition above, East Java, with a surplus of rice, is a main supplier for NTT, as presented in Tables 2.6 and 2.7 in Chapter 2. There is a seasonal variation in rice stock in the province, however. Figure 4.9 shows the rice stock in East Java, managed by BULOG, by month based on data available for the most recent three years. While it does not take account of rice traded in the private sector, Fig. 4.9 indicates that the rice stock is also regulated by a cycle of wet and dry seasons. The rice stock begins to build up around March and April after harvesting, peaks around May and June, starts to decrease afterwards, and reaches bottom around the year end, when East Java can less afford to supply rice to other provinces, including NTT.

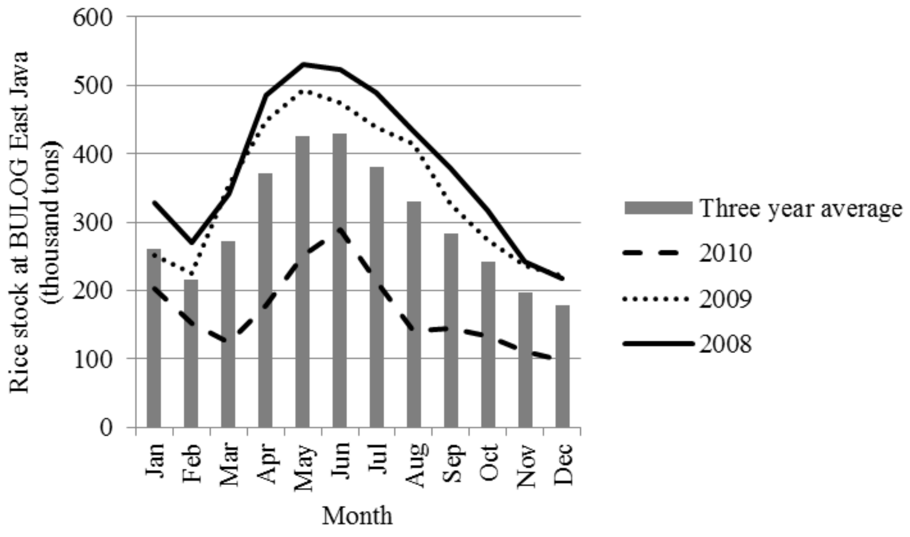

Fig. 4.9 Rice stock at BULOG by month in East Java (BPS East Java, 2009-2011a)

As for the second condition, Fig. 4.10 depicts the intra-annual variation in farmers' terms of trade, using data available for the most recent years, to gauge the ability to pay in NTT. It demonstrates that farmers, the most dominant group in NTT, are relatively better off after harvesting and worse off towards the year end before harvesting. There is a seasonal variation of livelihoods, which is also regulated by the intra-annual climate cycle.

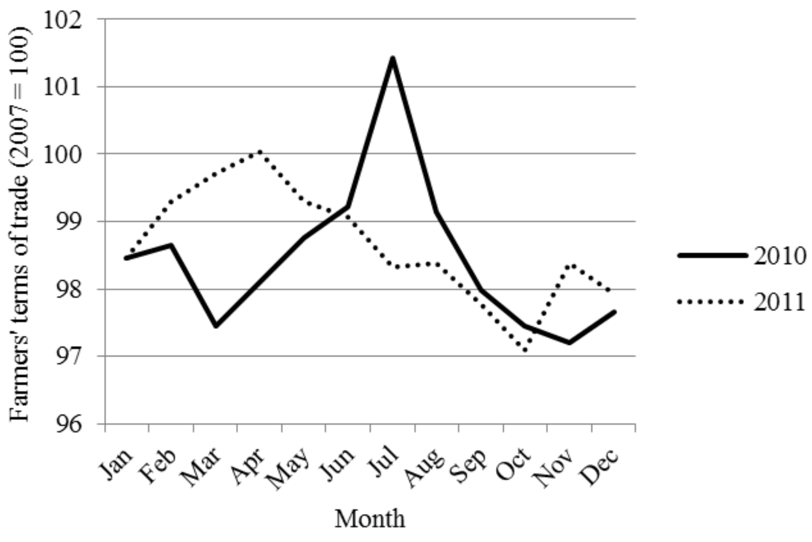

Fig. 4.10 Farmers' terms of trade in 2010 and 2011 in NTT (BPS NTT, 2011 and 2012)

Lastly, NTT depends on sea transport for rice supply from East Java. Gurning *et al*. (2010), however, document that the number of incidences of navigational warning and port accidents due to high waves has recently increased, as indicated in Table 4.3. According to LPEM-FEUI and The Asia Foundation (2010), strong winds and high waves occur in January and February, reducing the frequency of crossings to between 44% and 65% of the average number of crossings in NTT. These findings lead to the hypothesis that a strong wind may disrupt sea transport between Surabaya and Kupang, causing large differentials in food prices between the two cities in January. In this respect, Fig. 4.11 displays plots of monthly wind velocity in Surabaya on one hand, and excess monthly inflation rates of food in Kupang over Surabaya on the other, with some of the plots far above and below being dated. This, however, does not exhibit any clear relationship between the two sets of variables, and does not therefore support the above hypothesis. Similarly, monthly wind velocity in Kupang, for which data is only available for very recent years, does not have any clear relationship with excess monthly inflation rates of food in Kupang over Surabaya.

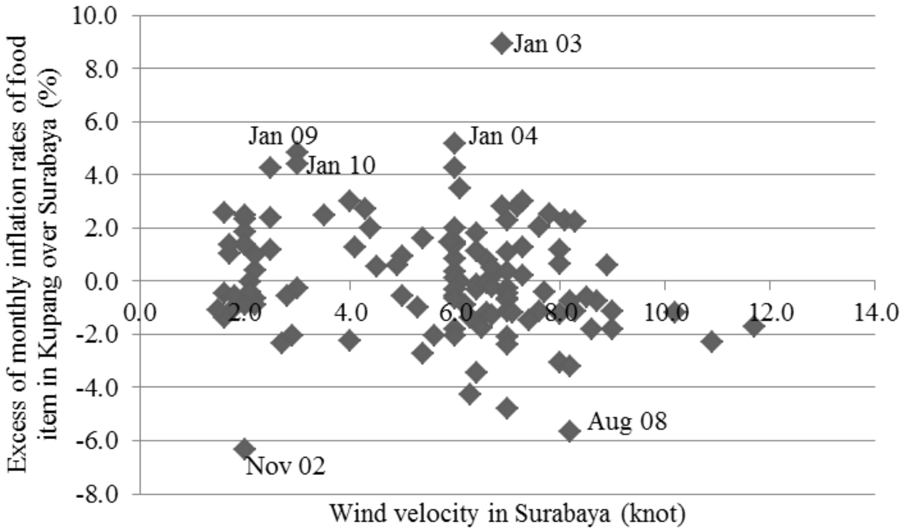

Fig. 4.11 Scatter plots of excess monthly inflation rates of food in Kupang over Surabaya against wind velocity by month in Surabaya from 2002 to 2010 (original data from BPS East Java, 2002-2011a; BPS NTT, 2002-2011)

4.4.3. Inter-annual factors for correlation of rice markets

As described before, a positive relationship is observed among the outlying plots dated January in Fig. 4.8. Among these plots, the inflation rates for January in Surabaya were relatively higher from 2006 to 2008, while lower in 2004 and 2009 (a very low inflation rate in January 2003 is considered as a reaction to a very high rate in November 2002). This is generally in line with the trend in the wholesale prices of rice, as illustrated in Fig. 4.3 and 4.4.

As for the plots outlying below, while some are dated April and May after harvesting, others include November 2002 and August 2006. It is difficult to identify factors responsible for the deviation of these plots, given the data available for this study; the following are plausible reasons. November 2002 is just before Idul Fitri in the year of El Nino. Idul Fitri is an important religious holiday among Muslims that marks the end of Ramadan, the Islamic holy month of fasting. As demand for food is strong among Muslims before Idul Fitri, the inflation rates of food prices become higher. Price movements in this relation are different between Surabaya and Kupang, as East Java is predominantly Muslim while NTT is Christian. The increase of food prices in Surabaya was exacerbated by El Nino, when more harvest failures than usual were anticipated.

August 2008 was in the midst of the Global Food Crisis, which started in late 2007 and peaked in mid-2008. As discussed by Dawe and Slayton (2010), the rapid increase of rice prices was attributed to multiple factors: expectations of an increasing demand for rice, imposition of export restrictions by major rice exporting countries, limited supply of other food crops such as wheat, increasing oil prices, use of food crops for biofuel purposes, and the weakening of the US dollar. In response, various policy measures were taken to reduce transmission of the international rice price spike to the Indonesian market. As documented by Salim (2010), while imports of rice were stopped, the rice allocation for poor families was increased twice in Indonesia. In order to meet these distribution needs, BULOG increased domestic rice procurement in surplus provinces, including East Java. BULOG distributed rice in deficient provinces, including NTT. A large amount of rice was transferred from surplus to deficient areas in 2008, which may account for the price change observed in August 2008.

This section showed that inflation rates are consistently higher in Kupang than Surabaya in January, the lean season in NTT. It indicates the seasonal weakening of the autonomous adaptation of the market. This may be associated with seasonality in the rice stock in East Java as well as the ability to pay in NTT, both of which are regulated by the intra-annual climate cycle. The present study does not support, however, the hypothesis that, by disrupting sea transport, strong wind may cause large differentials in food prices between the two cities in January. This study suggests that the seasonality of the market adaptive response is indirectly regulated by the intra-annual rainfall pattern.

4.5. Conclusion

The present study examined the status and change in rice distribution between provinces in Indonesia, and their associated climate and economic factors. It also analyzed adaptive responses of the markets between Surabaya and Kupang. These are relevant from a policy perspective. In the case, for example, where BULOG wants to sell rice to stabilize national rice prices in response to climate impacts, it would be irrelevant where rice is sold if the markets are well integrated. The excess of supply in a given place as a result of intervention would be transmitted to the rest easily. The present study found, however, that inflation rates are consistently higher in Kupang than Surabaya in January, the lean season in NTT, indicating seasonally weakening supply response to higher prices. The above findings suggest that, when and where seasonal factors are strong, government intervention for rice price stabilization to mitigate climate impacts, if it is centrally operated, is less effective. Instead, a more seasonally and geographically targeted intervention becomes necessary.

On the other hand, this study revealed the necessity of further research. In particular, the question remains why the autonomous adaptation seasonally weakens in the market between Surabaya and Kupang, while this was not the case in the rice markets across 19 regencies in Java during 1935-40, even though rice farming is regulated by the intra-annual rainfall pattern in both cases. One potential reason is that East Java and NTT are less integrated than the regencies within Java, but this needs to be scrutinized.

5. Assessment of Insurance for Paddy Production: A Case Study in East Java

5.1. Introduction

In an overview of the status and trend of Indonesian agriculture, Chapter 2 addressed, among others, the continued importance of the agricultural sector for rural development and employment despite its sharply reducing share in the national economy; decreasing support by the government; the resulting deterioration of the irrigation network as well as rural transportation; and increasing land use conversion from rice to cash crops and other profitable opportunities. It also found that climate impacts exacerbate these socio-economic problems concerning rice production and distribution. In order to tackle these difficulties, the Indonesian House of Representatives passed the Law concerning Protection and Empowerment of Farmers (Cabinet Secretariat of the Republic of Indonesia, 2013), which is widely considered as a milestone relating to agriculture and rural development. One of the measures stipulated in the Law is insurance. In this respect, the MoA is piloting an indemnity-based insurance scheme in order to apply the lessons learned to design a ministerial regulation for guiding implementation of the above Law. This chapter starts with an overview of the typology of adaptation options in agriculture to understand crop insurance as part of a broader risk management approach, which includes both structural and non-structural measures on a range of different spatial and temporal scales. With this background, the present study aims firstly to evaluate the pilot implementation of indemnity insurance in Indonesia. Secondly, it will assess the feasibility and scalability of weather index insurance if it would be applied in the same context as being piloted. Finally, it will discuss the limitations of insurance, no matter which type, as adaptation to climate impacts, and the necessity to design it as a part of the coherent set of adaptation actions.

5.2. Crop insurance and broader risk management approach

5.2.1. Typology of adaptation options in agriculture

Adaptation can take many forms, initiated by different stakeholders, to address risks and opportunities over a range of different spatial and temporal scales, and it includes both structural and non-structural measures. As discussed by Smit and Skinner (2002), adaptation options contain both structural measures, such as development of irrigation, and non-structural measures, such as land and water use and management practices, as listed in Table 5.1. At the same time, some adaptation options, such as technological development, are likely supported at the national level, while others, such as the improvement of production practices, take place at farmer level.

Table 5.1 Typology of adaptation options in agriculture (after Smit and Skinner, 2002)

Typology of adaptation in agriculture	Examples
Technological developments	
Crop development	New crop varieties to increase tolerance and suitability
Weather and climate information systems	Early warning systems that provide weather predictions and seasonal forecasts
Resource management	Water management, including irrigation, to address risk of water deficiencies
Government programs and insurance	
Agricultural subsidy and support programs	Insurance and income stabilization programs to influence farm-level risk management strategies Subsidy support and incentive programs to influence farm-level production practices
Resource management programs	Develop and implement polices to influence farm-level land and water use, and management practices
Farm production practices	
Farm production	Diversify crop types and varieties, crop substitution, to address environmental changes and economic risks Change intensification of production to address environmental change and economic risks
Land use	Change location of crop production to address environmental changes and economic risks
Irrigation	Implement irrigation practices to address water deficiencies, and risk of income loss
Timing of operations	Change timing of farm operations to address changes in growing seasons and conditions
Farm financial management	
Crop insurance	Purchase crop insurance to reduce risks of climate-related income loss
Income stabilization programs	Participate in income stabilization programs to reduce risks of income loss
Household income	Diversify source of household income to address risk of climate-related income loss

Table 5.2 Short and long-term adaptation options in agriculture (cited with modifications from Kurukulasuriya and Rosenthal, 2003)

Short-term
Crop insurance
Crop diversification
Replace plant types with new varieties; alternative production techniques; multi-cropping to defend against pests and diseases
Adjust timing of farm operations
Adjust cropping sequence; adjust timing of irrigation
Change cropping intensity
Adjust fertilizer and other inputs; change land use practices; change location of crop production; rotate or shift production between crops; change the timing of sowing, planting, spraying and harvesting
Temporary migration
Short-term weather forecasts
Food reserve and storage
Change crop mix
Adopt new crops; convert land use
Irrigation
Define land use and tenure rights to incentivize necessary investments in agricultural land to withstand climatic impacts
Efficient water use
Improve water distribution; promote irrigation efficiency to avoid salinization and increase in moisture retention; change crop and irrigation schedule for water storage and flood control; water recycling and conjunctive use of groundwater; rehabilitation and modernization
Both short and long-term
Investment promotion
Develop market efficiency
Adopt technological and other adaptation measures
Develop extension service to improve agricultural productivity, and raise awareness and knowledge of measures
Improve forecasting mechanism
Institutional strengthening and decision-making structures
Support long-term planning; reduce vulnerability; provide information on changing socioeconomic structure, demographics, technology, and public preferences; improve organizational capacity, responsibility and operational effectiveness

Another typology (Kurukulasuriya and Rosenthal, 2003) categorized adaptation according to temporal scales, as shown in Table 5.2. While many of the farm-level practices may be achieved in the short run, some adaptation options, such as improvement of institution and decision-making structures, are likely to require a longer time frame.

While Tables 5.1 and 5.2 indicate adaptation options in the agricultural sector, Turral *et al*. (2011) discussed the importance of making the linkage between water and agricultural policies more explicit in the context of competing demands for water and rising needs to maintain water allocation. This is associated with the linked effects of climate variability and change on water and agriculture, as illustrated in Fig. 5.1. In this respect, the study also presented types of actions for enhancing the security of water supply, as shown in Table 5.3, which indicates that many options to increase water storage capacity require structural responses.

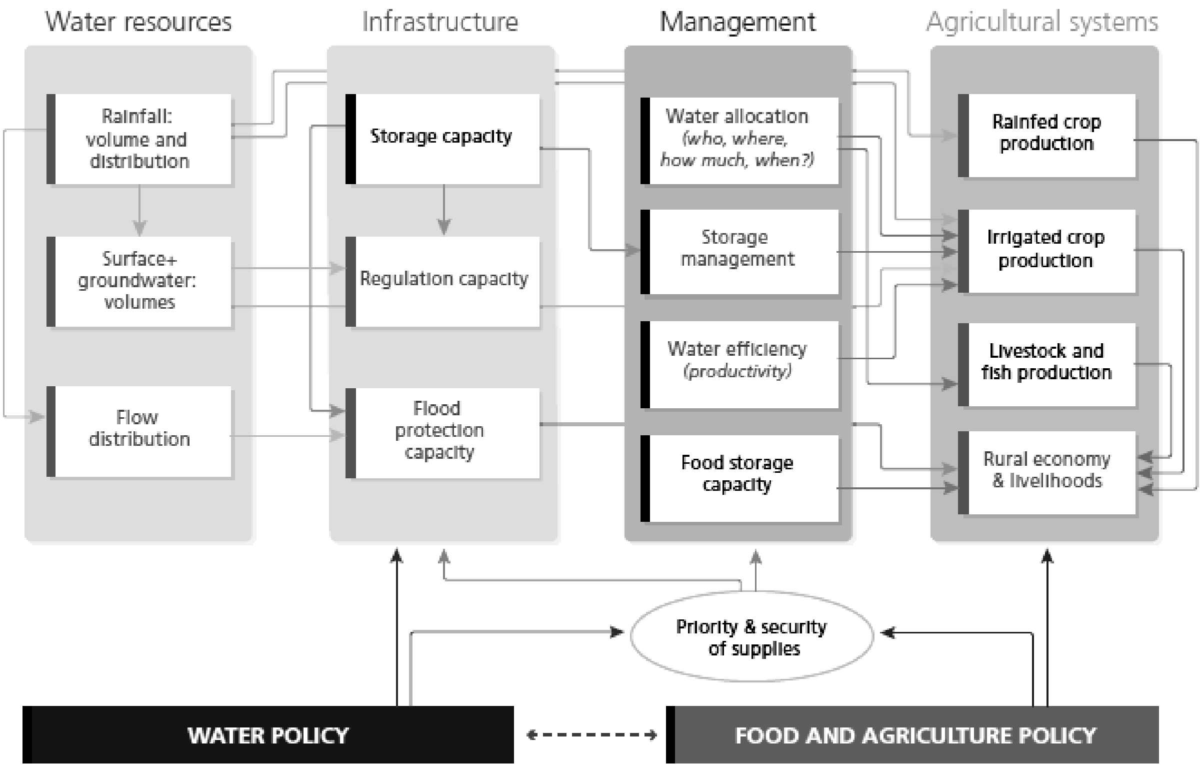

Fig. 5.1 Linkage of water and agricultural policies (cited from Turral *et al*., 2011)

Table 5.3 Options to enhance the security of water supply (after Turral *et al*., 2011)

Augment supply storage capacity to secure supplies
Increase surface water storage capacity
Construct a new dam
Modify operations of existing dams to increase usable storage
Pump out dead storage
Upgrade spillway capacity
Raise dam height
Increase groundwater storage
Increase within system storage (e.g., run-of-river system)
Construct balancing storage
Increase on-farm storage
Reduce transmission losses in water distribution
System configuration to improve hydraulic control and distribution, etc.

Crop insurance is one of the adaptation options in agriculture. As indicated in Table 5.1, at the government level, it is a tool to influence farmers in their risk management strategies, while at farmer level, it is used as a financial instrument to minimize income loss. In the meantime, Table 5.2 categorizes crop insurance as one of the short-term adaptation options. It is important to note that crop insurance is a part of a broader risk management approach, even broader when the linkage between water and agricultural policies is taken into account, which includes both structural and non-structural measures on a range of different spatial and temporal scales.

5.2.2. Insurance and insurability

According to Charpentier (2008), insurance is defined as the contribution of many to the misfortune of a few. Some risk adverse agents, called the insured, are willing to pay even more than the actual value of predictable risk to transfer its consequences to another agent, called the insurer. Hence, the fundamental concept is the mutualization of risks by the insurer.

Insurance is stipulated in Article 4.8 of the United Nations Framework Convention on Climate Change (UNFCCC) as one of the necessary actions ‘to meet specific needs and concerns of the developing country Parties arising from the adverse effects of climate change’ (UNFCCC, 1992). Charpentier (2008) indicates, however, that climate risks are becoming hardly insurable. Losses can be huge, and therefore the actuarially sound premium will be prohibitively high. Diversification may not be possible because of geographical correlation, and therefore a lot of additional capital will be required. The insurance market may not function since the price asked by insurance companies can be much higher than the price householders are willing to pay.

Berliner (1985) introduced nine criteria for differentiating between insurable and uninsurable risks: (1) randomness of loss occurrence, (2) maximum possible risk, (3) average loss amount upon occurrence, (4) average period of time between two loss occurrences, (5) insurance premium, (6) moral hazard, (7) public policy, (8) legal restrictions, and (9) cover limits. Berliner emphasized that a risk is not insurable for a professional risk carrier if at least one of the nine criteria is not satisfied. Due to its simple, but stringent and comprehensive approach, Berliner's set of insurability criteria is influential in the literature.

Table 5.4 Insurability criteria and related requirements according to Berliner (1985) (cited from Biener and Eling, 2012)

Insurability criteria			Requirements
Actuarial	(1)	Randomness of loss occurrence	Independence and predictability of loss exposure
	(2)	Maximum possible loss	Manageable
	(3)	Average loss per event	Moderate
	(4)	Loss exposure	Loss exposure must be large
	(5)	Information asymmetry	Moral hazard and adverse selection not excessive
Market	(6)	Insurance premium	Cost recovery and affordable
	(7)	Cover limits	Acceptable
Societal	(8)	Public policy	Consistent with societal values and availability of services
	(9)	Legal restrictions	Allow the coverage

Biener and Eling (2012) sorted the above-mentioned criteria into three categories that classify risks in terms of actuarial, market and societal conditions, as shown in Table 5.4. According to Biener and Eling (2012), to be insurable in actuarial terms, loss exposures must be independent, and loss probabilities must be able to be reliably estimated, the maximum possible loss per event must be manageable in terms of insurer solvency, the average loss amount per event must be moderate, loss exposure must be sufficiently large, and the potential problems resulting from information asymmetry cannot be excessive. The market conditions are satisfied if the insurance premium is adequate to provide cost recovery for the insurer, is affordable by the target population, and the policy’s cover limits are acceptable. With regard to the necessary societal conditions, coverage must be consistent with public policy, societal values and legal restrictions.

Biener and Eling (2012) found that the most severe insurability problems in the context of micro-insurance markets stem from the stochasticity and quantification of risks, moral hazard and adverse selection issues, and the size of the insurance premium. These are associated with problems arising from information asymmetries, as well as those due to a lack of data, undersized risk pools, and excessive transaction costs. Biener and Eling (2012) identified health and agricultural insurance as most affected by insurability problems, underlining that many solutions, including index-based insurance, have yet to be proven successful.

5.2.3. Crop insurance

Crop insurance has two major types: indemnity- and index-based. A number of studies (Skees and Barnett, 2006; Skees, 2008a, 2008b; Collier *et al.*, 2009; Smith and Watts, 2010) indicate that indemnity-based crop insurance is not sustainable. Claim payouts and administrative costs are often more than collected premiums, and therefore indemnity insurance has been rarely offered without government subsidy. Since the payouts are determined on the basis of individual harvests, an insurance agent has to verify the loss of each client. As described by Matsuda *et al*. (2013), however, the cost of obtaining accurate information on individual losses is prohibitively high, raising the problems of moral hazard and adverse selection.

An alternative type is weather index insurance, which has been implemented and studied in a number of countries, including Burkina Faso (Berg *et al*., 2009), China (Okhrin *et al*., 2013), Ethiopia (World Bank, 2006; Tadasse and Brans, 2012), India (Manuamorn, 2007; Cole *et al*., 2013), Malawi (Hess and Syroka, 2005; Gine and Yang, 2009; Syroka and Nucifora, 2010), Morocco (McCarthy, 2003), South Africa (Mapfumo, 2007), and Tanzania (Sarris *et al*., 2006). In weather index insurance, payouts are usually based on weather parameters, with rainfall data observed at a particular weather station being most widely used. As summarized by Matsuda *et al*. (2013), typical rainfall insurance starts with a contract by which an insurer indemnifies farmers for their losses if the amount of precipitation in a given phase is below or above the pre-determined level. The primary advantage of this insurance is that claim payments are made only on the basis of observable and verifiable index, not individual losses. The payouts are therefore independent of the characteristics and efforts of insured farmers, overcoming the problems of adverse selection and moral hazard. Besides, an insurance agent is not required to assess individual losses, ensuring prompt payments with minimum costs.

However, index insurance has its own disadvantages. The most notable problem is a so-called basis risk, a gap between an insured index and the risk it is meant to target. Barnett and Mahul (2007) identified two potential sources of a basis risk. Firstly, losses may be caused by disease, insect infestation, or other non-climate factors. Unless the weather variable, on which the index is based, is the dominant cause of loss in the area, a basis risk will be unacceptably high. Secondly, the weather variable used to drive the index may not be highly spatially covariate. The weather variable at target farms may be different from the measure at the weather station. Baethgen *et al.* (2010) put a basis risk in a different manner, defining it as a price paid for removing moral hazard, adverse selection and their resulting transaction costs which are inherent in indemnity-based insurance. Correlation of an index with the targeted loss is crucial if index insurance is to be an effective alternative to indemnity-based insurance. In this respect, feasibility also depends critically on the quality of official data and statistics.

Barnett and Mahul (2007) argue that the experiences with weather index insurance in developing countries are both too limited and too recent to draw conclusions about its long-run sustainability. According to their study, weather index insurance programs are currently most advanced in Mexico and India, where products focus primarily on rainfall deficiency (drought). Except for these two countries, however, sales have occurred within pilot programs, and therefore the volume of business has been marginal.

5.2.4. Pilot implementation of crop insurance in East Java

Pilot activity on indemnity insurance for paddy production was conducted by the MoA during the wet season from October 2012 to March 2013 in the regencies of Tuban and Gresik in the province of East Java (Pasaribu and Sudijanto, 2013). The pilot implementation was intended to provide inputs for drafting a ministerial regulation which will define operational details for implementation of the Law concerning Protection and Empowerment of Farmers.

The Law is aimed to support farmers, in particular small holding farmers, in the face of climate and economic impacts (Cabinet Secretariat of the Republic of Indonesia, 2013). The government measures stipulated in the Law include development and maintenance of agricultural infrastructure and facilities, stabilization of agricultural commodity prices, compensation of crop failure due to extraordinary events, development of an early warning system against adverse climate events, and agricultural insurance (Article 7). It is stipulated, among others, that agricultural insurance is aimed at protecting farmers from multiple perils, namely natural disasters, pests and diseases (Article 37). The government should provide support, including assistance of premium payment, in order for farmers to get access to insurance. It is also stipulated that the operation of agricultural insurance will be guided by the ministerial regulation to be formulated later by the MoA (Article 39). In this respect, the MoA has been implementing insurance on a pilot basis to design the above regulation.

Table 5.5 Features of pilot insurance in Indonesia (Pasaribu and Sudijanto, 2013)

Insurance holder	Farmer associations
Insured object	Paddy fields
Insurer	State-owned insurance company
Insurance period	One planting season (4 months from planting to harvesting)
Insurance value	6,000,000 Rp/ha
Insurance premium	180,000 Rp/ha (80% subsidized and 20% paid by farmers)
Risks covered	Flood, drought, pests and diseases

The pilot locations have been selected from paddy production centers in Indonesia. Participating farmers have to meet predetermined criteria, such as being a member of farmer associations. They also have to follow technical advice on paddy production to be provided by local agricultural agencies. Table 5.5 summarizes some of the key features of the pilot insurance. The insurance value is 6 million rupiah per hectare, which is the national average cost of paddy production per hectare. The premium is set to be 3% of the insurance value, with 80% being subsidized and 20% paid by farmers themselves. The risks to be covered are flood, drought, pests and diseases, each of which is defined in detail in the insurance policy. Losses are inspected by local agricultural agencies and reported to the state-owned insurance company. Claims are paid within 14 days after approval.

5.2.5. Pilot sites and the Bengawan Solo River Basin

The pilot sites, Tuban and Gresik, are regencies in the northern part of the province of East Java, one of the largest paddy production centers in Indonesia (Fig. 5.2). Tuban is located on the Java Ocean to the north border. The land area is about 1.8 thousand km^2, while the length of the Ocean front is 65 km. The population in 2010 was around 1.3 million (BPS Tuban, 2011). Gresik is located in the north-western part of Surabaya. Its area is about 1.2 thousand km^2, while the length of beach is 140 km. The population was around 1.3 million in 2011 (BPS Gresik, 2012).

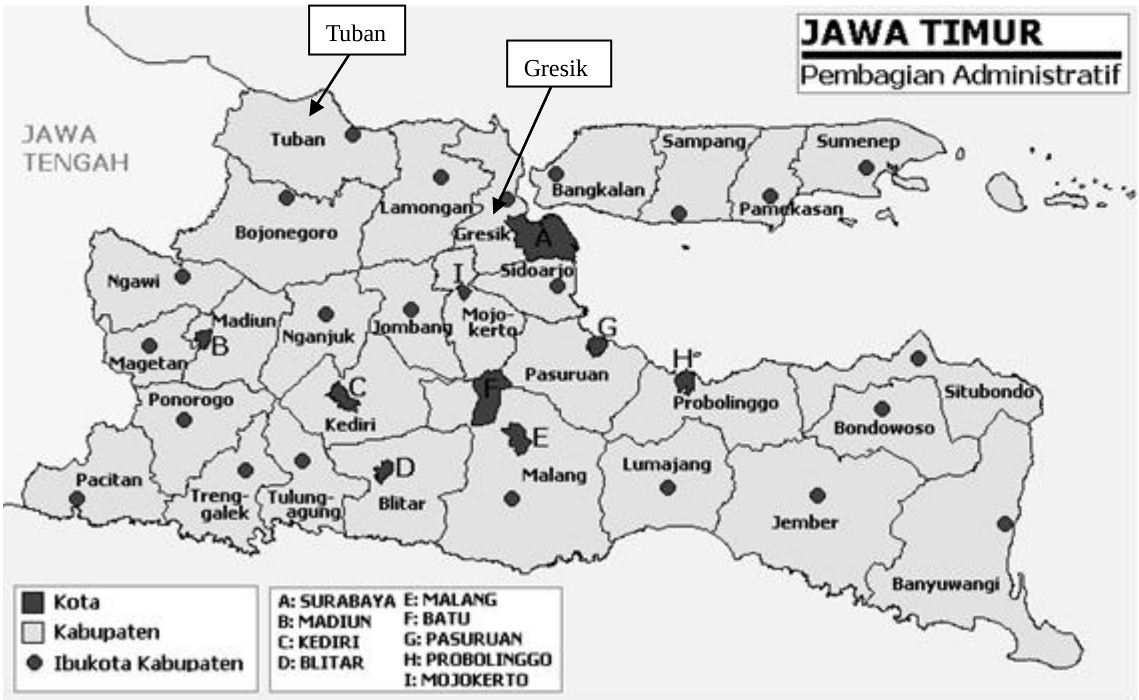

Fig. 5.2 Map of the regencies in East Java (cited from Mapsof.net, 2013)

The two regencies are both located in the Bengawan Solo River Basin (Fig. 5.3), which is the largest basin on the island of Java, belonging administratively to two provinces: Central Java and East Java. The majority of the Upper Solo River basin is a part of Central Java, while the majority of the Lower Solo River basin belongs to East Java, where the basin covers 9 regencies: Ponorogo, Madiun, Magetan, Ngawi, Bojonegoro, Tuban, Lamongan, Gresik and Pacitan. As documented by Hidayat *et al.* (2008), the population in the entire basin is estimated at around 16 million in 2005, with the population in the basin part of East Java being about 27.5% of the provincial total. The basin drains a watershed area of around 19,778 km^2 in total, discharging into the Java Sea at Gresik after travelling about 600 km from its spring in the Sewu Mountain Ranges in Central Java. During rainy seasons, the river inundates its corridor, bringing disasters to the inhabitants. The Lower Bengawan Solo is in particular flood prone. In late December 2007 to early January 2008, for example, heavy flooding and landslides resulted in numerous fatalities and crop losses.

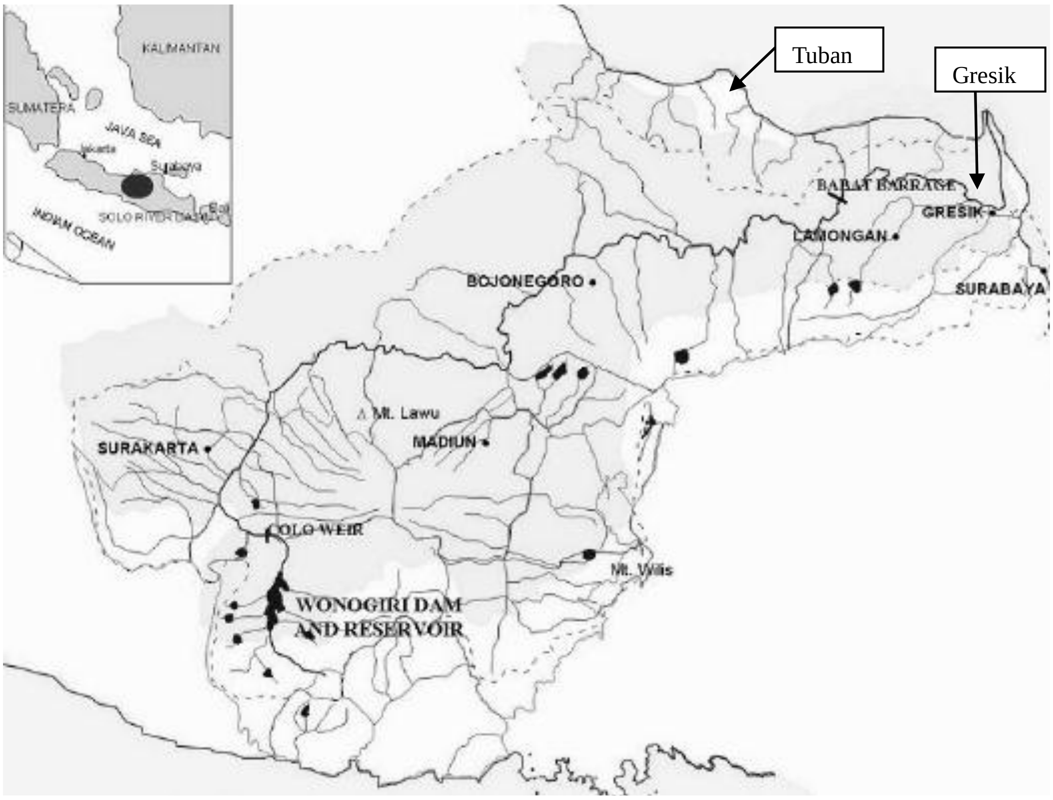

Fig. 5.3 Map of the Bengawan Solo River Basin (cited from NABRO, 2008)

5.2.6. Wonogiri multipurpose dam

According to Hidayat *et al*. (2008), the frequent floods in the Bengawan Solo River Basin are associated to a great extent with the declining function of the Wonogiri multipurpose dam (Fig. 5.4) as the sole larger reservoir and primary flood control facility in the basin. Due to population pressure, the reservoir catchment has been mostly cultivated with dry land farming that is highly fragile to surface soil erosion, while forest cover has drastically decreased. As a result, the Wonogiri reservoir is rapidly filled with sediments transported from the catchment, causing the effective reservoir capacity to substantially decrease. Since the frequent floods have negative impacts on agriculture in the river basin, it is important to make the linkage between water and agricultural policies explicit for considering a broader risk management approach, as discussed in the previous section.

As documented by JICA (2007), the Wonogiri multipurpose dam was completed in 1981. The mean annual inflow volume into the Wonogiri reservoir was approximately 1.23 billion m^3 in 1993-2005. The mean monthly inflow was the highest in February at 110.8 m^3/s, and reached its lowest in August at 2.3 m^3/s. For flood control, the reservoir water level is controlled so as not to exceed the elevation level (EL) of 135.3 m during the flood season, as illustrated in Fig. 5.5. The reservoir provides 220 million m^3 of flood control capacity, so as to regulate the peak discharge of 4,000 m^3/s to the regular outflow of 400 m^3/s.

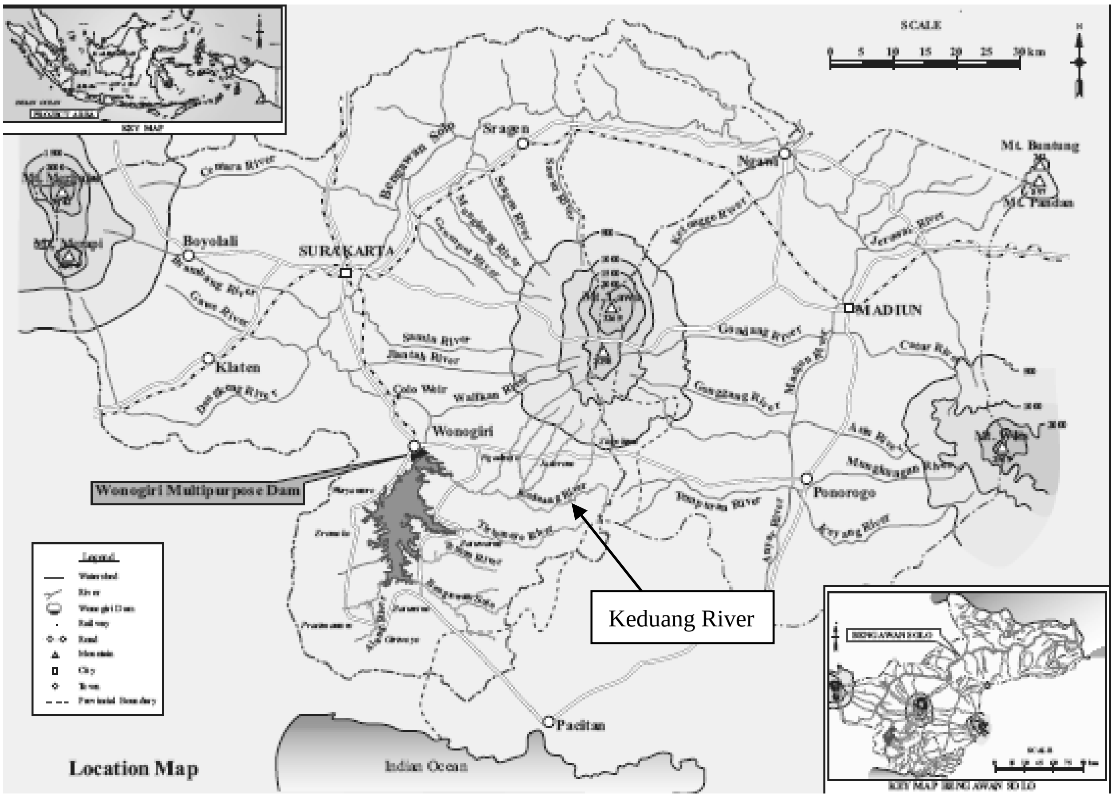

Fig. 5.4 Map of the Wonogiri multipurpose dam (cited from JICA, 2007)

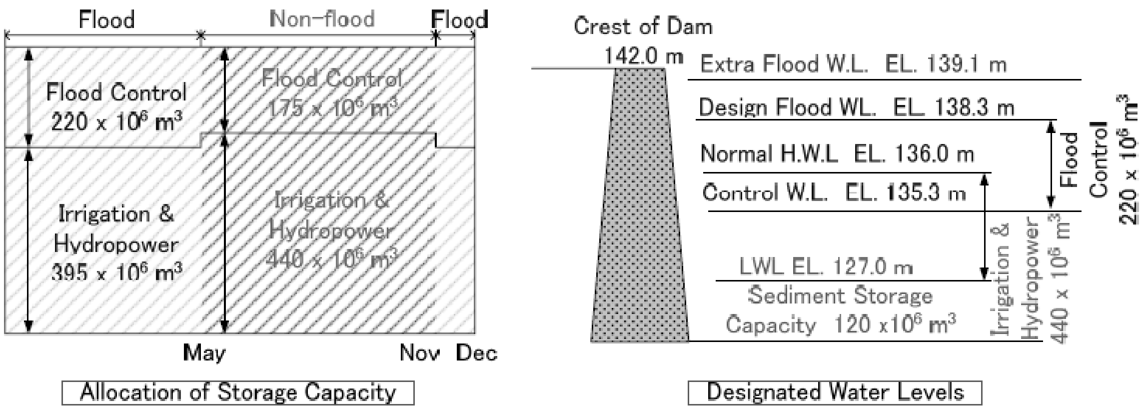

Fig. 5.5 Allocation of storage capacity and water levels of the Wonogiri reservoir (cited from JICA, 2007)

As surveyed by JICA (2007), the Wonogiri reservoir suffers from sedimentation deposits. The Keduang River that enters the reservoir is the primary cause of sediment-related problems. By 2005, a storage capacity of approximately 114 million m^3, or 16% of the original capacity of 735 million m^3, was lost due to sedimentation. It is projected that, without proper countermeasures, the Wonogiri reservoir would lose around 28% of its water use capacity and completely lose its sediment storage capacity by 2051, thereby no longer being able to provide its function of water supply and flood control. The main source of sediment is soil erosion, which is due to forest loss, as well as inappropriate land management and agricultural practices in the topographically critical area on steep mountain slopes.

The current annual sediment balance is illustrated in Fig. 5.6. According to the survey by JICA (2007), the annual average of sediment inflow into the Wonogiri reservoir in 1993-2005 was 3,180 thousand m^3, out of which the sediment inflow from the Keduang River was 1,220 thousand m^3, about 38% of the total inflow. On the other hand, the annual average of sediment outflow was 410 thousand m^3, out of which 150 thousand m^3 was released through the spillway and 260 thousand m^3 through the intake of the power plant. Hence, the annual sediment deposit in the sediment storage reservoir was 810 thousand m^3.

The priority countermeasures, as proposed by JICA (2007), are the combination of structural and non-structural measures to cope with the sediment inflow into the reservoir from the Keduang River. Watershed conservation in the Keduang sub-watershed, covering a total area of 11,260 ha with 83 villages, is a non-structural measure to reduce sediment inflow from its watershed. On the other hand, the construction of a new gate and spillway, as depicted in Fig. 5.7, is a structural measure to reduce sedimentation at the intake. According to JICA (2007), if realized, most of the sediment and garbage inflow from the Keduang River would be released from the new spillway. The above proposed actions are expected to achieve the annual sediment balance as depicted in Fig. 5.8. The sediment inflow would be reduced by 420 thousand m^3 per year, and the majority of the sediment inflow from the Keduang River would be released through the new spillway.

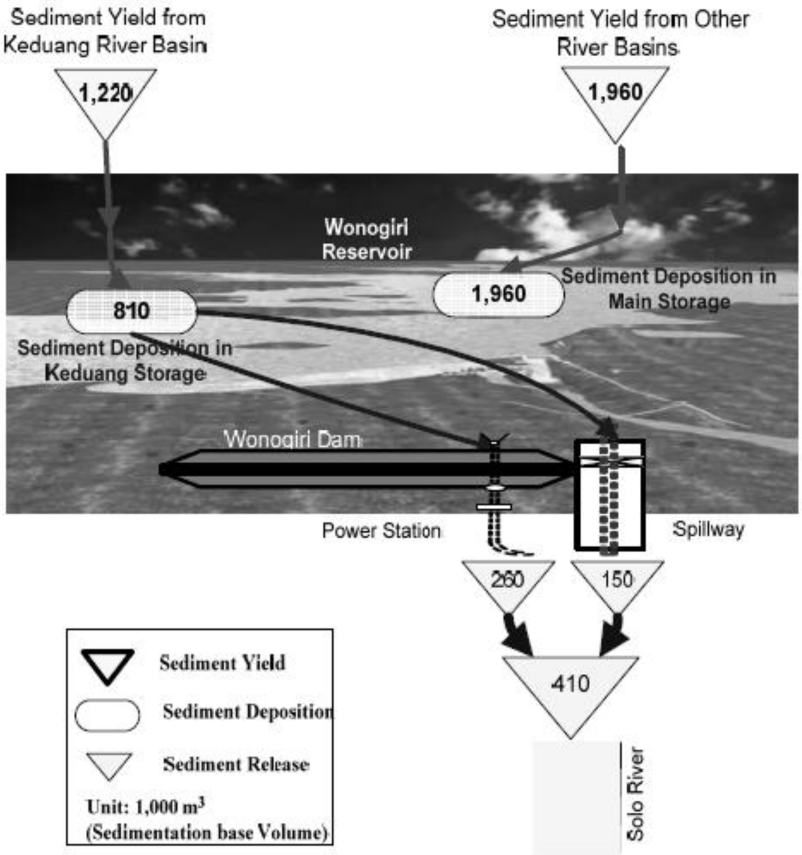

Fig. 5.6 Current annual sediment balance in the Wonogiri reservoir (cited from JICA, 2007)

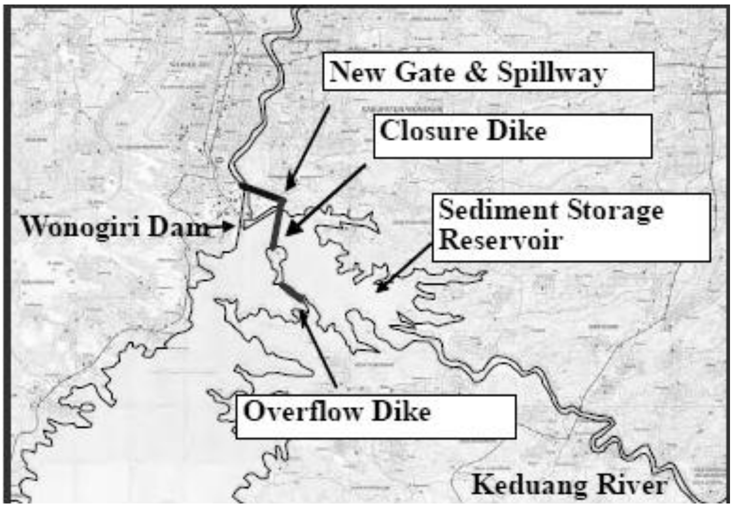

Fig. 5.7 General layout of structural measures against sediment inflow from the Keduang River (cited from JICA, 2007)

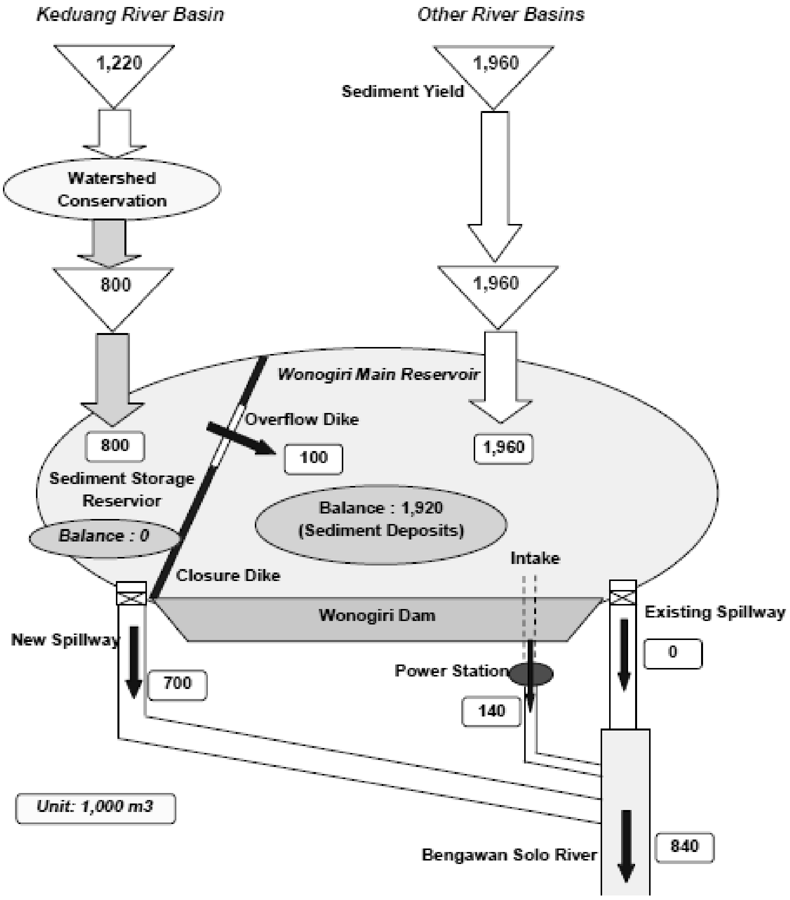

Fig. 5.8 Design annual sediment balance in the Wonogiri reservoir (cited from JICA, 2007)

5.3. Methods

The present study evaluated the pilot insurance conducted by the MoA, starting with the review of Pasaribu and Sudijanto (2013), who were commissioned by the JICA project ‘Capacity Development for Climate Change Strategies in Indonesia’ to make a rapid assessment of the above pilot activity. The pilot regencies, Tuban and Gresik in East Java, were also visited in April 2013 to obtain a general understanding of their climate and socio-economic conditions. The potential problem of adverse selection was considered using historical data on monthly rice harvest failures in the pilot regencies, which was available from BPS East Java. The feasibility of weather index insurance in the same context as being piloted above was analyzed on scatter plots between historical data on rainfall and rice harvest failure by month from 2000 to 2010 in the pilot regencies. Both datasets are available from BMKG and BPS East Java for this study. Locally observed rainfall data was used for this study, since this is the parameter on which the weather index insurance is most frequently based. Only monthly rainfall data, however, is available for this study, even though other data, such as daily rainfall or maximum daily rainfall per month, would be more preferable. The issue of scalability of index insurance was analyzed by comparing correlation coefficients of rice harvest failures on one hand and rainfall amounts on the other, both on a monthly basis, across the regencies in East Java. The comparison was made in terms of distributions of the correlation coefficients of 406 pairs of regencies. The data on rice harvest failures was available at BPS East Java from 2000 to 2010. Monthly rainfall data for all of the regencies was available at BPS East Java, however, only from 2001 to 2005 for the present study. The assessment of insurability of the pilot insurance was made in reference to the criteria developed by Berliner (1985).

5.4. Evaluation of crop insurance

5.4.1. Evaluation of pilot insurance

The result of the pilot insurance is summarized in Tables 5.6 and 5.7. As documented by Pasaribu and Sudijanto (2013), the area of insured paddy field in East Java was 470.87 ha, with 320.00 ha in Tuban and 150.87 ha in Gresik. By the end of the insurance period, payment was made to cover the indemnity due to floods for 80.00 ha of paddy fields in Tuban. The flood was associated with overflow of the Bengawan Solo River in January 2013, which inundated paddy fields and caused harvest failures in the surrounding areas, such as the districts of Sokosari and Rengel, in Tuban, as was also reported in the local media (Antara News East Java, 2013; The Jakarta Post, 2013).

Table 5.7 presents the amounts of collected premium and paid indemnity for the pilot insurance. While the total collected premium was about 85 million rupiah, the total paid indemnity amounted to 480 million rupiah, which was more than five times higher than the received premium. Besides, only 20% of the premium payment was borne by farmers themselves. The remaining premium needed to be subsidized. Administrative costs for the verification of individual claims are not included in Table 5.7. All of these indicate that the pilot insurance is far from actuarially sound. Moreover, in Tuban, where the indemnity was paid, floods have occurred during every wet season in recent years, most notably in January 2008, as indicated in Table 5.8, raising a potential problem about adverse selection.

Table 5.6 Result of pilot implementation of crop insurance in East Java: Crop areas insured and claimed (original data from Pasaribu and Sudijanto, 2013)

Location	Crop area insured (ha)	Crop area claimed (ha)	Type of claim
Tuban, East Java	320.00	80	flood
Gresik, East Java	150.87	0	-
Total	470.87	80	-

Table 5.7 Result of pilot implementation of crop Insurance in East Java: Collected premium and paid indemnity (original data from Pasaribu and Sudijanto, 2013)

Crop area insured (ha)	(A)	470.87
Unit premium (Rp/ha)	(B)	180,000
Unit premium subsidized (Rp/ha)		144,000
Unit premium paid by farmers (Rp/ha)		36,000
Total premium collected (Rp)	(C)=(A)*(B)	84,756,600
Crop area claimed (ha)	(D)	80
Unit indemnity (Rp/ha)	(E)	6,000,000
Total indemnity paid (Rp)	(F)=(D)*(E)	480,000,000
Payout ratio	(G)=(F)/ (C)	5.66

Table 5.8 Area of rice harvest failure during wet seasons over the last five years in Tuban (ha) (BPS East Java, 2006-2011b)

	Oct	Nov	Dec	Jan	Feb	Mar	Total
2005/06	0	0	25	0	36	0	61
2006/07	0	0	0	175	0	0	175
2007/08	0	0	1,418	4,643	486	1,151	7,698
2008/09	0	116	0	0	905	1,829	2,850
2009/10	0	0	0	113	78	111	302

5.4.2. Assessment of feasibility and scalability of weather index insurance

This section considers the feasibility of weather index insurance if it would be applied in the same context as being piloted. Figures 5.9 and 5.10 are scatter plots of rainfall and rice harvest failure by month from January 2000 to December 2010 in Tuban and Gresik, respectively. In both diagrams, some plots are located far above the approximation line, indicating that some large farm losses have happened irrespective of locally observed rainfall, raising the issue of basis risk. In the case of Tuban (Fig. 5.9), most of the plots outlying above are observed during wet seasons, suggesting that floods during rainy seasons are significant risk factors for paddy production in the regency. A tremendous farm loss was observed in January 2008, when intense rainfall in upper parts of the Bengawan Solo River resulted in heavy floods in the basin. The loss recorded in that month has little to do with the locally observed rainfall. The case of Gresik (Fig. 5.10) is also similar. Even though the severity of losses has not been as significant as that of Tuban, large losses have been mostly observed during wet seasons, suggesting that floods are main risk factors there as well.

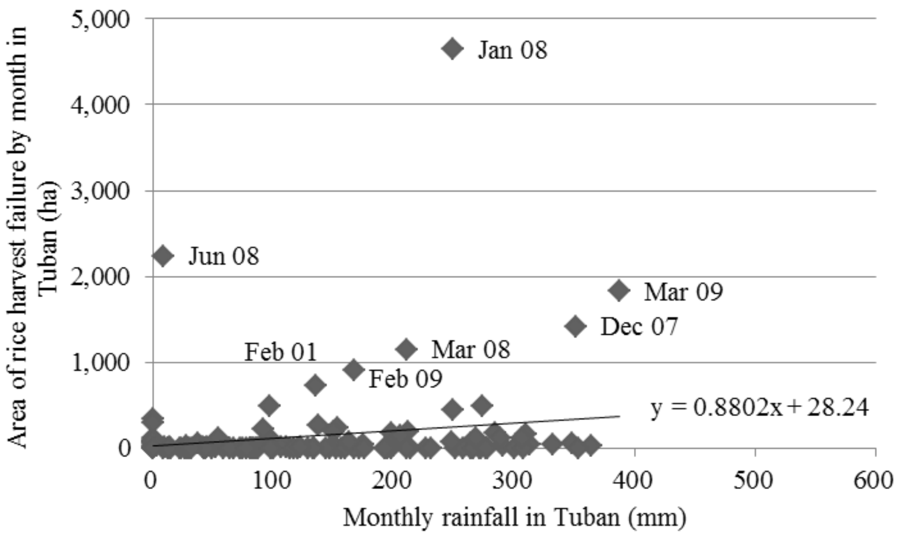

Fig. 5.9 Scatter plots of monthly rainfall and rice harvest area in Tuban from January 2000 to December 2010 (original data from BPS East Java, 2001-2011b; BMKG, 2013)

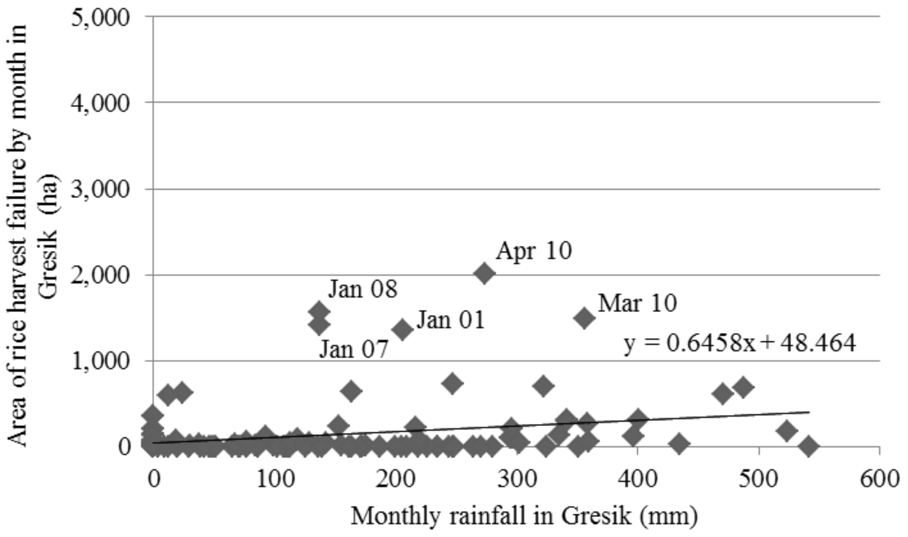

Fig. 5.10 Scatter plots of monthly rainfall and rice harvest failure in Gresik from January 2000 to December 2010 (original data from BPS East Java, 2001-2011b; BMKG, 2013)

The above findings suggest that locally recorded rainfall, on which weather index insurance is most frequently based, cannot be a good proxy for the risk that it is meant to cover. In particular, a basis risk is likely to be significant in the river basin, where losses have more to do with rainfalls observed in the upstream area. This risk becomes even more substantial in extreme events, such as the floods in January 2008, when farmers are in most need of support. This is a situation, as discussed by Syroka and Nucifora (2010), where weather index insurance may require other contingency plans.

There is also a problem associated with scaling up weather index insurance to the provincial level. Table 5.9 compares the data concerning correlation coefficients of (1) rice harvest failures by month from 2000 to 2010 across the regencies in East Java, (2) those only during wet seasons given the fact that rice harvest failures have occurred most substantially during wet seasons in the province, as indicated in Fig. 5.11, and (3) rainfall amounts by month from 2001 to 2005. The coefficients of rice harvest failures are generally low, suggesting the failures are likely to be area-specific. The coefficients during wet seasons, however, are relatively higher. This is attributed to higher correlations among regencies located in the Bengawan Solo River, in particular those located in the midstream area, such as Pacitan, Magetan, Bojonegoro and Tuban, suggesting that floods associated with overflow of the river are common risks for these regencies. Table 5.9, on the other hand, exhibits significantly higher correlation coefficients of monthly rainfall across the regencies. These findings, in combination, indicate firstly that, in the case of East Java, rice harvest failure is more area-dependent than rainfall is, suggesting that a basis risk would potentially increase as the insured area is extended. Secondly, due to high correlation of rainfall across the regencies, insurers may be exposed to more systematic weather risk as they expand business geographically. As discussed by Okhrin *et al.* (2011), from a risk management point of view, systematic risk becomes a serious issue when the insured area expands, having been one of the main reasons for failures of private crop insurance.

Table 5.9 Correlation coefficients of monthly rice harvest failures and rainfall amounts in regencies in East Java (original data from BPS East Java, 2001-2011a)

	Correlation coefficients of monthly rice harvest failures across regencies for both wet and dry seasons from 2000 to 2010	Correlation coefficients of monthly rice harvest failures across regencies for wet season from 2000 to 2010	Correlation coefficients of monthly rainfall amounts across regencies from 2001 to 2005
Total number of pairs of regencies	406	406	406
Distribution			
More than 0.90	0	2	18
0.80 - 0.90	3	3	176
0.70 - 0.80	1	7	150
0.60 - 0.70	4	8	53
0.50 – 0.60	2	8	8
Less than 0.50	396	378	1
Average	0.07	0.07	0.78
Mean	0.01	-0.02	0.79
Maximum	0.88	0.97	0.93
Minimum	-0.08	-0.18	0.46

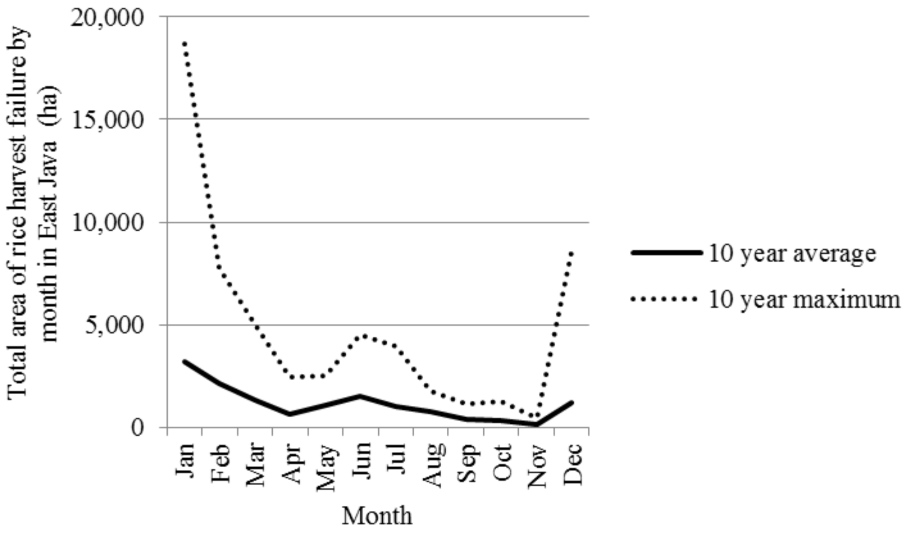

Fig. 5.11 Total area of rice harvest failure by month in East Java (original data from BPS East Java, 2001-2011b)

5.4.3. Assessment of insurability

The above findings suggest that severe problems originate from stochasticity of risks and the size of premium, as summarized in Table 5.10. The randomness of loss occurrence is not assured since floods have recently occurred in the river basin in almost every wet season. The premium is not adequate for the insurer to cover the cost. It is not affordable for farmers unless it is subsidized. These problems exist no matter whether indemnity- or index-based insurance is chosen. As some of the insurability criteria are not satisfied, the risks intended to be covered by the pilot insurance in East Java are considered as not insurable for a professional risk carrier (Berliner, 1985). In fact, this is the reason why public support for insurance is necessary in East Java.

In this respect, Collier *et al.* (2009), OECD (2011) and Anton *et al.* (2012) discuss a risk that public support for insurance schemes may impede adaptation actions by encouraging farmers to maintain unsustainable practices. This is highly relevant for risk management for farming in a river basin, where floods result from an interaction of multiple factors. As discussed by Skees *et al*. (2008), when farmers purchase insurance, they transfer production risk to the insurer. However, the risk transfer in itself does not address the underlying problems. The sedimentation problems and the resulting loss of flood control capacity at the Wonogiri multipurpose dam, as examined by Hidayat *et al.* (2008) and JICA (2007), are some of the underlying problems for the frequent occurrence of floods in the Bengawan Solo River Basin. Unless these problems are addressed by other adaptation measures, the risks may become hardly insurable. A combination of structural and non-structural adaptation options in agriculture, as listed in Tables 5.1 and 5.2, along with flood control measures, as indicated in Table 5.3, need to be designed in a coherent manner. In this respect, the levels of insurability for crop insurance with and without other adaptation options will need to be studied to examine the coherence of having insurance as a part of a broader risk management approach.

Table 5.10 Assessment of insurability of pilot insurance in East Java (with reference to Berliner, 1985; Biener and Eling, 2012)

	Insurability criteria		Assessment of pilot insurance in East Java
Actuarial	(1)	Randomness of loss occurrence	Floods have recently occurred in the river basin in almost every wet season.
	(2)	Maximum possible loss	Still pilot-based, but geographical expansion would bring about systematic risk.
	(3)	Average loss per event	Still pilot-based.
	(4)	Loss exposure	Still pilot-based.
	(5)	Information asymmetry	Problems of moral hazard and adverse selection may be addressed by an index-based insurance.
Market	(6)	Insurance premium	Not adequate for the insurer. Not affordable for farmers unless subsidized.
	(7)	Cover limits	Still pilot-based.
Societal	(8)	Public policy	Based on the Law concerning Protection and Empowerment of Farmers.
	(9)	Legal restrictions	Based on the Law concerning Protection and Empowerment of Farmers.

5.5. Conclusion

The present study found that pilot indemnity insurance is costly with a potential problem of adverse selection. Replacing it with weather index insurance, however, would bring about the problem of a basis risk, even if it would properly address the problems of moral hazard and adverse selection. The issue of a basis risk is significant in a river basin, where floods are not only due to a particular weather parameter, on which the index would be based, but also result from an interaction of multiple factors. The risks intended to be covered by the pilot insurance in East Java are deemed to be not insurable for a professional risk carrier. The severe problems stem from stochasticity of risks and the size of premium. The randomness of loss occurrence is not assured since floods have recently occurred in the river basin in almost every wet season. The premium is not adequate for the insurer to cover the cost. It is also not affordable for farmers unless it is subsidized. These problems exist no matter whether indemnity- or index-based insurance is chosen. The present study suggests that a coherent set of structural and non-structural response measures needs to be designed without overreliance on public support for insurance schemes.

6. Conclusion

This thesis arises from a concern about food security in Indonesia, the world's fourth most populous country, under the impacts of climate variability and change. The present study targets rice, the staple food of most of her population, and focuses on its availability, in particular rice production and distribution.

The overall objective of this study is to assess climate and socio-economic impacts on food security, and evaluate market and policy responses in Indonesia. In order to achieve this objective, the present study addressed three research components. Firstly, it examined the combination of climate and socio-economic factors that contributed to land use conversion from rice production to oil palm plantation. Through focus group meetings and interviews, four factors were extracted as most relevant for affecting the change in land use: (1) climate conditions, (2) economic environment, (3) rice planting index, and (4) distance from palm oil enterprise estates. When unusual climate conditions were observed, the rice harvest area substantially decreased. Economic conditions, most notably the price difference between oil palm and rice, incentivized land use conversion. The remaining two factors - rice planting index and the proximity to palm oil mills - differentiated the rice farmers' responses.

Secondly, this study analyzed adaptive responses of rice distribution between different locations. It found that the differentials in inflation rates are consistently greater in a particular month, indicating seasonally weakening supply response to higher prices. The above finding suggests that, when and where seasonal factors are strong, government intervention for rice price stabilization to mitigate climate impacts, if it is centrally operated, is less effective. Instead, a more seasonally and geographically targeted intervention becomes necessary.

Thirdly, this paper presented an overview of adaptation for rice production, and evaluated crop insurance as a part of a broader risk management approach. In particular, it examined pilot indemnity insurance under implementation for rice farmers, and assessed the feasibility and scalability of weather index insurance if it would be applied in the same context. This study found that the pilot indemnity insurance is costly. Replacing it with weather index insurance, however, would bring about the problem of a basis risk, since harvest failures are not only due to a particular weather parameter, on which an index would be based, but also result from an interaction of multiple factors.

The above findings have important policy implications. The literature (Adger *et al.*, 2005; Adger and Vincent, 2005; Osbahr *et al*., 2010; Vincent *et al*., 2013) cautions that whether or not adaptation is successful, is often dependent on scale. In case of farmers, for example, who convert their land use from rice production to oil palm plantation, it may be considered as a good adaptation, as oil palm is more resilient to rainfall variability. The large scale of the conversions, however, is a threat to the food security of the society as a whole. Along with exhibiting a spatial dimension, adaptation also has a temporal dimension. Crop insurance is one of the examples. When farmers purchase insurance, they are able to transfer production risk to the insurer in the short run. However, the risk transfer in itself does not address the underlying problems of climate and socio-economic impacts on rice production. Unless these problems are addressed by other measures, the risks may continue to increase and become hardly insurable in the long run.

The above observation indicates that government countermeasures may face trade-offs between various adaptation actions, and between adaptation and other development priorities over different spatial and temporal dimensions. It suggests the importance of evaluating particular adaptation actions from different scales to identify potential trade-offs and understand the sustainability of the proposed actions. It also underlines the importance of planning a coherent set of structural and non-structural response measures. In order for the crop failures concerned to be insurable, for example, other adaptation measures, including structural responses for strengthening flood control capacity, as discussed in this paper, need to be designed in tandem.

This study also reveals the necessity for further research on the policy, institutional mechanisms and procedures for resolving the above-mentioned trade-offs. In this context, criteria and indicators for assessing and prioritizing the trade-offs need to be developed.

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